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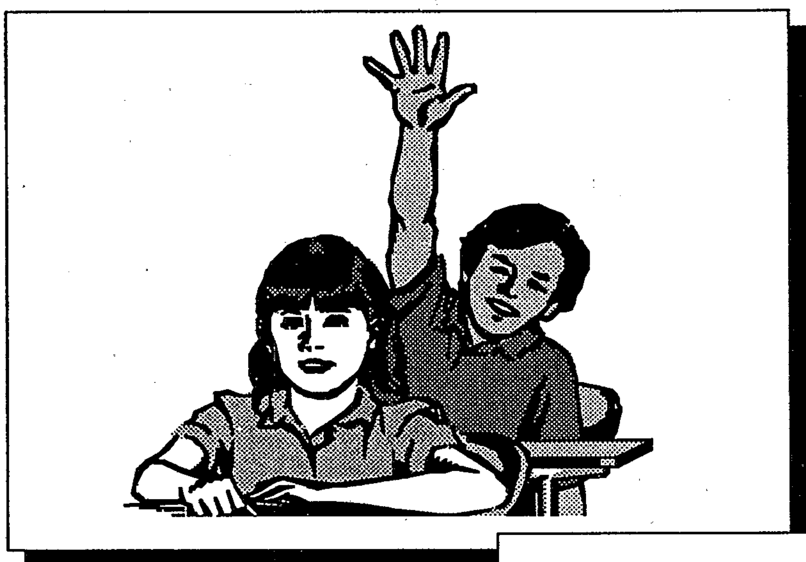
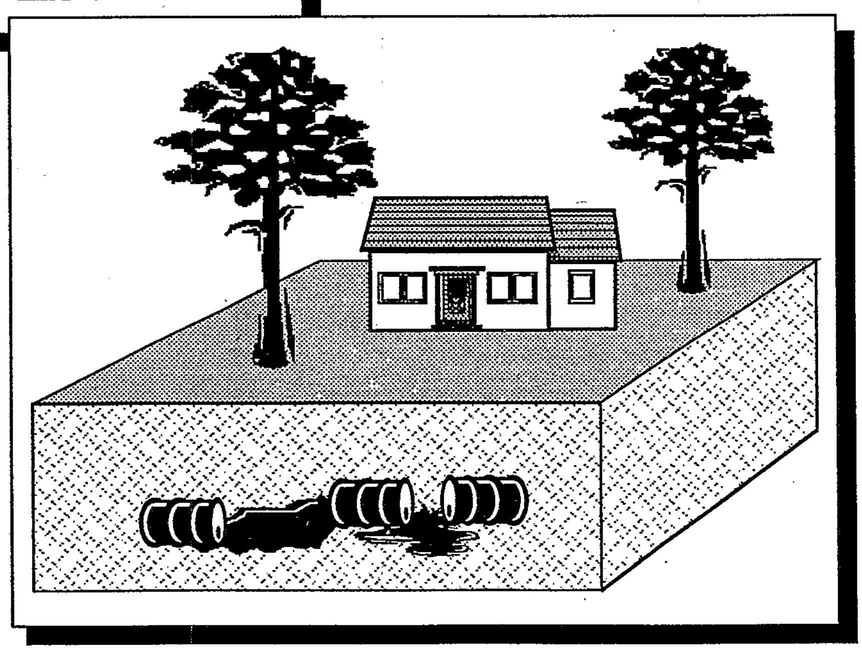
HAZ-ED
Classroom Activities for Understanding Hazardous Waste





FOREWORD

HAZ-ED

Classroom Activities for Understanding Hazardous Waste

One out of four Americans lives within four miles of a Superfund hazardous waste site. There are Superfund sites and many other hazardous waste sites in every state. Every community generates hazardous waste.

The Federal Superfund Program, administered by the U.S. Environmental Protection Agency (EPA), investigates and cleans up hazardous waste sites throughout the United States. Part of this program is devoted to informing the public and involving them in the process of cleaning up hazardous waste sites from beginning to end. Haz-Ed was developed to assist EPA's efforts. Haz-Ed assists educators in teaching 7th through 12th grade students about hazardous waste, environmental issues surrounding site cleanup, and the Federal government's Superfund Program.

Haz-Ed can be used as part of a larger curriculum, as special stand-alone activities, or on an occasional basis to teach students about hazardous waste issues. Haz-Ed is a compilation of interdisciplinary activities that focus on the often complicated and sometimes controversial scientific, technical, and policy issues related to hazardous waste sites and Superfund. It is designed to help students develop skills in critical thinking, problem solving, and decision making. It also increases environmental awareness and encourages an environmental ethic in students.

EPA hopes Haz-Ed will be beneficial to you in your efforts to educate your students about the environment and the environmental concerns we all share. If you have any questions concerning Haz-Ed or the Superfund Program, please contact Nancy L. Cronin of Superfund's Community Involvement and Outreach Center, at 703-603-9097.

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INTRODUCTION

Ten million children under the age of 12 live within 4 miles of a Superfund site. The following education materials were developed to focus the attention of 7th through 12th grade students on hazardous waste, environmental issues surrounding hazardous waste sites, and the Federal government's Superfund Program. The units in this package are designed to help students think critically and creatively about hazardous waste pollution problems and some alternatives for resolving them. The units are interdisciplinary, with a particular focus on classroom interaction and real-world applicability. They are readily usable in schools with a team-teaching or theme approach. The materials are designed for use in a range of subject areas. A table showing the related subject areas for all units is provided at the end of this Introduction for quick reference.

The Haz-Ed materials focus on laws passed by the United States Congress and implemented through regulatory programs directed by Federal agencies, primarily the U.S. Environmental Protection Agency. These are Federal laws and programs that apply to the entire nation. Each state also has a system of environmental laws and state agencies to implement them. Even some local governments have acted to deal with environmental issues through legislation. Although beyond the scope of this document, information about state and local activities can be very useful to you.

Instructional Goals

The units are designed to fulfill four primary instructional goals. Each unit is hands-on and interactive, giving students practice in:

- Collecting, analyzing, and interpreting data in experiments that illustrate the impact of hazardous waste pollution
- Clarifying value systems—their own and those of others—that impact how we perceive and treat the environment
- Analyzing how economics, laws, politics, technology, and other factors contribute to hazardous waste pollution and the process of dealing with it
- Assessing alternatives for resolving hazardous waste pollution problems.

Students must gain an understanding of the scientific and technical concepts related to the environment, and see that these concepts are useful and applicable in the world. To show the relevance and utility of the concepts and skills underlying these activities beyond the classroom, many of the units challenge students to extrapolate real world applications from the information presented.

What This Package Contains

The package includes 6 **Warm-up Exercises**, 13 **Activities**, and 11 **Fact Flashes**. These units focus on the most important hazardous waste and site cleanup issues in a simple, straightforward style. Many of them can be completed in one class period, but some require two class periods or portions of several classes over a specified period of time. The number of class periods required for each lesson was determined based on an average class period of 45 minutes. These are estimates and are provided only as a guide. The actual time required will depend on the grade level and the skill level of the students in the class.

Pieces can be used alone or in various combinations to accommodate the needs of individual classes and grade levels. Some educators, for example, may choose to conduct several Warm-ups and Activities in sequence over an entire semester. Complementary units are referenced in each Warm-Up and Activity.

Several lessons begin with homework assignments to prepare students for the exercise. Most units call for explanations or presentations by teachers, but several also involve presentations from students and facilitated discussions led by teachers.

Fact Flashes

The **Fact Flashes** are a set of fact sheets that provide the foundation of information on which the Warm-Ups and Activities are built. The Fact Flashes stand alone and can be used to supplement your lessons in a number of ways.

Warm-Up Exercises

The **Warm-Ups** focus on developing and understanding some basic concepts related to hazardous waste. These exercises are designed to be presented by classroom educators in series or as preparation for related Activities.

Activities

The **Activities** build on the Warm-ups, although they can stand alone. Students examine issues related to hazardous waste and site cleanup. The Activities are designed for presentation by classroom educators. Since some of the Activities take more than one class period, however, educators may wish to consider sharing the delivery with an invited guest, such as an EPA Superfund staff member or an employee of the state government's hazardous waste cleanup program.

Purpose explains what the student will know or be able to do following this activity.

Duration estimates the time needed for the lesson. The actual time required will depend on the grade level and the skill level of the students in the class.

Grade Level indicates the target grade levels for this unit.

Key Terms/Concepts shows terms students will encounter in the unit (defined in the Glossary section of the package).

Suggested Subjects are the scholastic subject areas to which the lesson is related.

Background contains basic facts and context information for the educator's use.

Preparation provides a list of materials and steps the educator should complete prior to class.

Procedure sets out step-by-step instructions for executing the lesson. Wherever appropriate, this section includes questions the educator should ask or anticipate from the students, student worksheets, and answer keys.

Activity 1

Waste: Where Does It Come From? Where Does It Go?

Duration	2 class periods
Grade Level	9-12
Key Terms/ Concepts	Hazardous waste
Suggested Subjects	Biology Chemistry

Purpose

In this lesson, students use a map to identify and locate potential sources of hazardous waste in their neighborhood or community. In the process, students learn what hazardous waste is and identify the potential threats it poses.

Background

Our lifestyles are supported by complex industrial activities that produce vast quantities of waste. Industries that produce our clothing, cars, paper, medicines, plastics, electronic components, fertilizers, pesticides, and cosmetics—to name only a few—use and discard thousands of hazardous chemicals and other substances every year.

Preparation

1. Place the map on an easel or hang it on a wall where students can see it.

Procedure

1. Summarize information found in Fact Flash 1 and your research in preparing the class, including how hazardous waste sites are created from a variety of sources.

Extension (Optional)

- Allow the class to choose specific ideas they want to pursue and design a plan of action. Monitor and facilitate their progress until completion.

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Extension (Optional) offers ideas for carrying the lesson further by suggesting follow-up, extra-credit activities, or ways to expand participation beyond the classroom.

Appended Materials

At the end of this document you will find several resources and supplements that can assist you in making the most of Haz-Ed or support your independent activities. The **Glossary** defines many of the terms and concepts students will encounter in the exercises and activities. You may consider providing your students with a copy for their general reference.

A list of abstracted **Suggested Readings** provides both educators and students with additional information. The list is keyed for grade level and provides references to the most relevant exercises and activities.

A list of **Contacts and Resources** provides a variety of information, including key phone numbers and Internet addresses.

A brochure, ***This Is Superfund,*** is a stand-alone document that describes the Superfund Program. It can be used in the classroom and the community.

Finally, the **Bibliography** lists resources used in preparing the Haz-Ed materials.

How To Use This Package

These materials are intended as resources. Educators should feel free to make adjustments in the material to fit in with topics and concepts the class may already be studying or to address topics of particular importance to students in a given geographic area. Also, we encourage educators to use their knowledge of the make-up of the community to add texture to the lessons and reinforce students' in-classroom work. Educators are reminded to consider economic and cultural sensitivities in using the materials that involve living creatures or procuring materials.

How educators and guest presenters deliver these lessons is all-important. Helping students think critically about the world around them and their role in preserving the environment underlies all the materials. Many of the activities involve technical vocabulary and concepts, and instructors may need to spend extra time defining terms and providing background. Accelerated students may not have a problem, but others may. Grade levels listed in the materials are only suggestions; select and adapt these materials to your students' abilities and needs. Feel free to copy these materials and share them with other educators.

Most units provide questions to stimulate student discussion, but few have a single, "right" answer. These questions are intended to draw on the students' abilities to identify various options, strategies, and reasons in arriving at their answers. Educators can ask students to describe how they arrived at a particular answer and encourage them to compare their answers and approaches with those used by other students to answer the same question. Where there may be several answers to the same question, challenge students to explore why answers are different and how to determine which, if any, are correct. This approach helps students develop critical thinking skills in a stimulating, noncompetitive environment.

Subject Areas for *Haz-Ed* Lessons

	Biology	Chemistry	Civics/Government	Creative Writing	Drama	Earth Science	English	Geography	Geology	Health	History	Journalism	Life Science	Mathematics	Physical Science	Physics	Social Studies
Warm-up 1										✓			✓		✓		✓
Warm-up 2			✓										✓		✓		✓
Warm-up 3														✓			
Warm-up 4	✓	✓		✓			✓						✓	✓	✓		
Warm-up 5		✓		✓				✓			✓	✓	✓		✓		✓
Warm-up 6						✓									✓		
Activity 1	✓	✓								✓			✓		✓		✓
Activity 2		✓				✓			✓						✓		
Activity 3			✓												✓		✓
Activity 4		✓													✓		
Activity 5	✓	✓											✓				
Activity 6	✓	✓											✓		✓		
Activity 7		✓				✓			✓						✓		
Activity 8	✓	✓	✓										✓		✓	✓	
Activity 9			✓		✓					✓			✓		✓		✓
Activity 10		✓	✓											✓	✓		✓
Activity 11			✓		✓												✓
Activity 12			✓														✓
Activity 13				✓	✓		✓					✓	✓				✓

WARM-UPS

Warm-Up 1

Defining Hazardous Waste

Duration	1 class period
Grade Level	7-10
Key Terms/ Concepts	Corrosive Hazardous Substance Hazardous Waste Ignitable Reactive Toxic
Suggested Subjects	Health Life Science Physical Science Social Studies

Purpose

In this exercise, students define and explore the relationship between hazardous substances and hazardous waste. The exercise allows them to identify a number of commonly used toxic chemicals, describe how these materials are used and disposed of, and sort them into the various types of hazardous waste. Students then discuss how the improper use and disposal of these materials can affect people in their community and the environment.

Background

Many familiar products contain hazardous substances. Hazardous substance is a broad term that includes many chemicals and materials, including poisonous or **toxic** chemicals. Improper use and disposal of these products can result in the production of **hazardous waste** that can pollute our environment. Becoming more aware of the hazardous substances we encounter every day and of the types of hazardous waste they produce is the first step in learning how to properly handle and dispose of them, thereby protecting ourselves and our environment.

Fact Flash 1: Hazardous Substances and Hazardous Waste describes these terms and their application. For more information on hazardous substances, see the Suggested Reading list found at the end of the Haz-Ed materials. Other Haz-Ed materials that are related to this topic include *Fact Flash 7: Pollution Prevention* and *Activity 10: Pollution Prevention.*

Preparation

1. Gather the following materials:

    - Copies for each student of *Fact Flash 1: Hazardous Substances and Hazardous Waste.*

2. Read Fact Flash 1 to prepare for the lesson.

3. Distribute Fact Flash 1 to the students and have them read it as homework.

Procedure

1. Ask students what a **hazardous substance** is. Have them write their definitions on a sheet of paper or share them with the class. Record them on the chalkboard.

2. Define hazardous substances for the class:

    Hazardous substances are materials that present a threat or potential risk of injury to people or the environment when they are produced, transported, used, or disposed of.

3. Discuss characteristics of hazardous substances. To be hazardous, a substance must have one or more of the following characteristics:

    - **Corrosive** — capable of chemically wearing substances away (corroding) or destroying them. For example, most acids are corrosive. They can eat through metal, burn human skin on contact, and give off vapors that burn the eyes. Acids found in batteries are corrosive.

    - **Toxic** — poisonous to people and other organisms. Toxic substances can cause illness—ranging from severe headaches to cancer—and even death if swallowed, and many also can be absorbed through the skin. Pesticides, weed killers, and many household cleaners are toxics.

    - **Ignitable** — capable of bursting into flames. Ignitable substances pose a fire hazard and irritate the skin, eyes, and lungs. They also may give off harmful vapors. Gasoline, paint, and furniture polish are ignitable substances.

- **Reactive** — capable of exploding or releasing poisonous gas when mixed with another substance or chemical. For example, chlorine bleach and ammonia are reactive. When they come into contact with each other they produce a poisonous gas.

(NOTE: You may want to bring to class examples, such as those mentioned above, of the various types of household products that can become hazardous waste. Use caution in handling these products.)

4. Discuss with the class some types of hazardous substances that may be found in their community.

5. Divide the class into 4 or 5 small groups. Distribute *Fact Flash 1: Hazardous Substances and Hazardous Waste* and have the students read it.

6. Write the questions below on the board, or make copies for the students. Have each group discuss the questions. Explain that each group should be prepared to participate in a class-wide discussion later in the period. Allow about 20 minutes for group discussion.

   - What household chemicals do people have in their homes or garages that are hazardous and that could become hazardous waste?
   - Do you think you or your family contribute to the hazardous waste problem? If so, how?
   - What problems could you, your family, and the community face as a result of being exposed to hazardous waste?
   - What businesses in your community do you think might use hazardous materials?
   - What are some ways hazardous waste problems can be prevented? Which of these things can you do? *(Give 1 or 2 examples, such as using vinegar and water to clean windows and not using pesticides on plants.)*

7. After about 20 minutes, have the class reassemble. Take each question in turn and have students share the concerns, opinions, and questions raised in their groups. You may want to have one or two students write unanswered questions and suggestions for preventing hazardous waste problems on the chalkboard for everyone to see.

8. About 5 minutes prior to the end of the period, summarize the discussion and identify subjects students may want to explore more fully in subsequent classes.

9. Introduce the concept that there are simple steps the students, their families, and the community can take to decrease and prevent pollution. *Fact Flash 7: Pollution Prevention* provides additional information. *Activity 10: Pollution Prevention* presents some ideas for students to explore and contains a handout on nontoxic alternatives that can be used around the house in place of cleaning fluid, laundry detergent, pesticides, and so forth. You can copy and distribute this handout to the class if desired.

Extensions (Optional)

- Have students list chemical products in their homes and sort them into groups according to the types of hazardous waste they could produce (for example, lawn and garden pesticides belong in the "toxic" category, gasoline and lighter fluid belong in the "ignitable" category). *NOTE: Caution your students not to touch any of these substances while they are making their lists.*

- Have students contact the local government environmental services office or sanitation department and find out about recycling and other programs designed to minimize hazardous waste. For example, have them find out how used paint thinner and leftover paints should be disposed of in their community.

- Have students contact local gasoline service stations, oil change and auto lubricating shops, and nursery and garden supply companies and report on how these firms are required to dispose of hazardous substances.

- Have students contact your state environmental departments and ask if they have any posters or materials that show how to dispose of hazardous substances and hazardous waste, or that illustrate the use of alternatives to hazardous substances. Get some of these materials to use in your school for a display on Earth Day, Arbor Day, or other environmental event.

Warm-Up 2

EPA's Superfund Program: Overview

Duration	1 class period
Grade Level	7-12
Key Terms/ Concepts	Early Action Emergency Response Cleanup Hazardous Waste Long-term Action Potentially Responsible Party Superfund
Suggested Subjects	Civics/Government Life Science Physical Science Social Studies

Purpose

Students become familiar with the goals of the Superfund Program, and the means by which those goals are achieved. The principal goal of the Superfund Program is to reduce and eliminate threats to human health and the environment posed by closed or abandoned hazardous waste sites. Students become familiar with the different ways the U.S. Environmental Protection Agency (EPA) responds to threats posed by hazardous waste, how hazardous waste sites are characterized and cleaned up, and the role of the local community in the process.

Background

Hazardous waste comes from a variety of sources, from both present and past activities. Years ago, before we understood the dangers of hazardous waste, there were no laws controlling its disposal. Many businesses and industries treated their hazardous waste the same as the rest of their trash—so it ended up in a landfill, dumped in a river or lake, or buried in the ground.

Eventually, thousands of uncontrolled or abandoned hazardous waste sites were created in abandoned warehouses, manufacturing facilities, harbors, processing plants, or landfills. The **Superfund** Program was created in 1980 to investigate and clean up hazardous waste sites nationwide.

Fact Flash 2: The Superfund Cleanup Program provides a good overview of what EPA is trying to accomplish with the Superfund Program. Superfund is a nickname for the law that requires EPA to take care of hazardous waste sites, and gives them legal power to force the people who created the sites to clean them up or repay the government for its cleanup efforts. The nickname comes from a trust fund that provides money for investigating and cleaning up these sites.

The Superfund Program refers to the work EPA does to clean up abandoned hazardous waste sites. The Superfund Program also responds to emergencies such as a fire in a chemical plant where poisonous gas might be released, or a highway accident involving a tractor-trailer that is carrying hazardous material. In these situations, as always, EPA's first responsibility is to protect the health and safety of the people, plants, animals, and waterways in the area from immediate danger.

For more information on the Superfund program, see the Suggested Reading list found at the end of the Haz-Ed materials. Other Haz-Ed materials that are related to this topic include *Warm-Up 6: What is an Aquifer?* and *Activity 2: Examining a Hazardous Waste Site.*

Preparation

Option 1: Video and Discussion/Review

1. Gather the following materials:

   - VCR and monitor
   - EPA videotape *This is Superfund* (available from NTIS; information on ordering is given at the end of this document)
   - Copies for each student of the Student Worksheet, *Understanding Superfund: A Quiz To Test Your Knowledge,* and the brochure, *This Is Superfund* (found at the end of the Haz-Ed materials).

2. Read *Fact Flash 2: The Superfund Cleanup Program* to prepare for discussion.

Option 2: Lecture and Demonstration

1. Gather the following materials:

   - 3 clear glass or plastic cups (9 oz. each)
   - red food coloring
   - vegetable oil
   - maple syrup
   - copies for each student of the Student Worksheet, *Understanding Superfund: A Quiz to Test Your Knowledge*, and the brochure, *This is Superfund.*

2. Read *Fact Flash 2: The Superfund Cleanup Program* to prepare your lecture. Read *Activity 2: Examining a Hazardous Waste Site* for information on the way different contaminants behave in an aquifer.

Procedure

Option 1: Video and Discussion/Review

1. Distribute the Student Worksheet, *Understanding Superfund: A Quiz To Test Your Knowledge,* and instruct the class to read and complete the quiz. Allow 4 or 5 minutes for the completion of the quiz.

2. Outline the activities comprising this exercise:

   - The quiz will be reviewed and some answers discussed.
   - A videotape entitled *This is Superfund* will be shown (if available).
   - A brief lecture on the Superfund Program will be presented.
   - Correct answers to the quiz will be provided.
   - A discussion of the program and a question-and-answer session will end the class.

3. Review the quiz. Ask volunteers to provide their answers, but do not provide the correct answers (which will come later). Ask the class if anyone knows of any Superfund sites. Have they ever wondered how Superfund sites are discovered? Do they know how the risks at the site are assessed? Do they know how sites are cleaned up? Who is responsible for performing these tasks and why?

4. If students volunteer some familiarity with the program or a site, have them share their knowledge with the class. The site may be local, or it may be one of the better known sites across the country. If appropriate, locate a nearby site for the class and briefly describe the situation. *(NOTE: Information on individual sites is available from EPA's Regional Office for your state. A list of EPA's Superfund Community Involvement Offices for each Region is found in the materials at the end of this document.)*

5. Show the videotape *This is Superfund.* If you are unable to show the video, use the information in Fact Flash 2 and the brochure, *This is Superfund,* to explain the program to the students.

6. Discuss the video, restating some of the highlights of the presentation. *(NOTE: If you are not familiar with the program, you may want to view the video or read through the brochure* This is Superfund *prior to the classroom discussion of the program.)*

7. Review the answers to the quiz in light of the video. (See *Instructor's Answer Key,* attached.) Distribute the brochure, *This is Superfund.*

8. Discuss the assessment process by which sites are discovered and risks are determined. Note that sites can be discovered by anyone, and that there is a hotline for reporting potential sites.

9. Discuss the site cleanup process and the importance of the potentially responsible parties. The class should understand that Superfund is not a "public works" program under which the government takes responsibility for the cleanup of sites. Rather, the government attempts to identify PRPs and encourages them to undertake the cleanups. If the parties are unwilling to undertake the cleanup, the government may compel the parties to do so by court order, or may elect to perform the cleanup and recover costs from the responsible parties.

10. The discussion session should be interactive; ask the class questions as well as answer them. Types of questions for the class to consider include a discussion of why there are uncontrolled hazardous waste sites, why the government looks for PRPs rather than performing cleanups, why some cleanups take a long time, and the consequences for the public if there were no Superfund Program.

11. Assign *Fact Flash 2: The Superfund Cleanup Program* for homework.

Option 2: Lecture and Demonstration

1. Distribute the Student Worksheet, *Understanding Superfund: A Quiz to Test Your Knowledge*, and instruct the class to read and complete the quiz. Allow 4 or 5 minutes for the completion of the quiz.

2. Outline the activities comprising this exercise:
   - The quiz will be reviewed and some answers discussed
   - A brief lecture on the Superfund Program will be presented
   - Correct answers to the quiz will be provided
   - A demonstration of the behavior of different contaminants in water will be presented.

3. Review the quiz. Ask volunteers to provide their answers, but do not provide the correct answers (which will come later). Ask the class if anyone knows of any Superfund sites. Have they ever wondered how Superfund sites are discovered? Do they know how the risks at the site are assessed? Do they know how sites are cleaned up? Who is responsible for performing these tasks and why?

4. If students volunteer some familiarity with the program or a site, have them share their knowledge with the class. The site may be local, or it may be one of the better known sites across the country. If appropriate, locate a nearby site for the class and briefly describe the situation. *(NOTE: Information on individual sites is*

available from EPA's Regional Office for your state. A list of EPA's Superfund Community Involvement Offices for each Region is found in the materials at the end of this document.)

5. Perform the demonstration.

   a. Fill each of the 3 cups with water.

   b. Discuss how different types of wastes call for different types of action or cleanup methods.

   c. Add a drop of red food coloring into the first cup. What happens? How would you clean this up? The red food coloring simulates the behavior of gasoline or other water-soluble contaminant in water.

   d. Add a drop of vegetable oil to the water in the second cup. What happens? How would you clean this up? The vegetable oil simulates the behavior of a light non-aqueous phase liquid (LNAPL), such as jet fuel. LNAPLs are lighter than water but do not mix with water.

   e. Add a drop of maple syrup to the water in the third cup. What happens? How would you clean this up? The maple syrup simulates the behavior of a dense non-aqueous phase liquid (DNAPL), such as TCE. DNAPLs are heavier than water but do not mix with water.

   f. These demonstrations illustrate some of the contaminants found at a Superfund site. *Warm-Up 6: What is an Aquifer?* and *Activity 2: Examining a Hazardous Waste Site* examine the behavior of pollutants in groundwater in greater detail.

6. Review the answers to the quiz in light of the lecture. (See Instructor's Answer Key, attached.) Distribute copies of the brochure, *This is Superfund*, to the students.

7. Discuss the assessment process by which sites are discovered and risks are determined. Note that sites can be discovered by anyone, and that there is a hotline for reporting potential sites.

8. Discuss the site cleanup process and the importance of the potentially responsible parties. The class should understand that Superfund is not a "public works" program under which the government takes responsibility for the cleanup of sites. Rather, the government attempts to identify PRPs and encourages them to undertake the cleanups. If the parties are unwilling to undertake the cleanup, the government may compel the parties to do so by court order, or may elect to perform the cleanup and recover costs from the responsible parties.

9. The discussion session should be interactive; ask the class questions as well as answer them. Types of questions for the class to consider include a discussion of why there are uncontrolled hazardous waste sites, why the government looks for PRPs rather than performing cleanups, why some cleanups take a long time, and the consequences for the public if there were no Superfund Program.

10. Assign *Fact Flash 2: The Superfund Cleanup Program* for homework.

Extensions (Optional)

Break the class into groups and make assignments for presentations during a follow-up class. The number of groups may vary, but each should include about 5 or 6 students. Give them a week or more to complete the research and prepare their reports.

Encourage group members to discuss among themselves how best to accomplish the research required, make contact with appropriate sources of information, conduct interviews, compile information, structure the presentation, and prepare to answer questions posed by other students. Below are some topics and recommended resources the students could use.

1. **Local Emergency Response** — This group should report on how chemical spills and other hazardous substances emergencies are handled in this community. While the EPA has the power and ability to respond to emergencies, typically the first response will be from the local fire department or other emergency management team. Students should report on the roles different local, state, and Federal agencies play in responding to emergencies. Does one group assess the extent of damage and another clean up hazards? How do the agencies interact and coordinate their efforts?

2. **Local or State Superfund Site** — By contacting the EPA Regional Community Involvement Coordinator (CIC) for your state (see the *This is Superfund* brochure), students can choose a nearby Superfund site or a site within the state for research. Information can be collected from the Regional CIC or from a nearby Superfund Information Repository. A Superfund Information Repository is a place near each Superfund site where information about the site is kept for public review. Typically, these repositories are at public libraries. This group should make a presentation on the information available for that site. The report could include:

   - The contaminants found at the site
   - The contaminated media (soil, rivers, lakes, groundwater, or air)
   - Whether any responsible parties have been identified
   - Who is paying for the cleanup
   - Any technologies that are being used to treat the contamination
   - Any other pertinent information.

The content of the report will depend on how far along the site is in the Superfund process. Sites where cleanup action is already underway would be the most interesting. Note that information on more than one site can be presented; each group can make a presentation on a different site. This will emphasize the different types of hazardous waste sites cleaned up under the Superfund Program. If you live in an area with a significant number of sites, you may consider having each group make a presentation on a different local site.

When each group gives its presentation, allow other students to ask questions. Ask group members what problems, if any, they encountered in preparing their presentations. Ask if they uncovered information or met people who were particularly surprising or interesting.

Instructor's Answer Key

Warm-Up 1: Understanding Superfund — A quiz to test your knowledge

1. **What is Superfund?**

   a. A Federal program that cleans up the nation's worst hazardous waste sites.

   d. A fund of money made up of Federal tax revenues used to pay for hazardous waste site cleanups.

2. **What is meant by the term "hazardous waste?"**

   a. By-products of society that can pose a substantial or potential threat to human health or the environment when improperly managed.

   c. A waste product with one or more of the following characteristics: ignitable (it can catch fire easily), corrosive (it can eat away material), reactive (it causes a violent or harmful reaction), or toxic (it is poisonous).

3. **Who is responsible for cleaning up hazardous waste sites?**

   a. The U.S. Environmental Protection Agency.

   b. State and local environmental agencies.

   c. The U.S. Coast Guard.

   d. Organizations and people responsible for contamination at the sites.

4. **Who pays for the sites to be cleaned up?**

   a. Organizations and people responsible for contamination at the sites.

   b. EPA through the Superfund trust fund, if responsible parties cannot be identified or cannot perform the cleanup.

   d. Federal agencies, such as the U.S. Department of Energy, that are responsible for site contamination.

Understanding Superfund: A quiz to test your knowledge

Circle every answer to a question that you think is a correct response.

1. What is Superfund?

a. A Federal program that is in charge of all environmental laws of the United States.
b. A Federal program that cleans up the nation's worst hazardous waste sites.
c. A collection of all Federal and state laws that regulate hazardous materials.
d. A fund made up of Federal tax revenues used to pay for hazardous waste site cleanups.

2. What is meant by the term "hazardous waste?"

a. By-products of society that can pose a substantial or potential threat to human health or the environment when improperly managed.
b. Mercury in a thermometer.
c. A waste product with one or more of the following characteristics: ignitable (it can catch fire easily), corrosive (it can eat away material), reactive (it reacts violently or harmfully), or toxic (it is poisonous).
d. What you had for dinner last night.

3. Who is responsible for cleaning up hazardous waste sites?

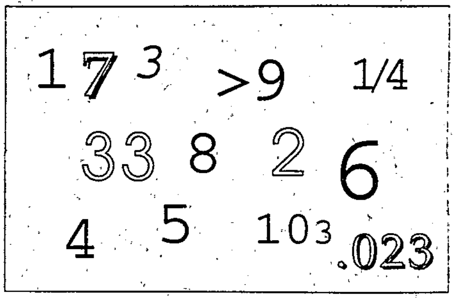
a. The U.S. Environmental Protection Agency.
b. State and local environmental agencies.
c. The U.S. Coast Guard.
d. Organizations and people responsible for contamination at the sites.

4. Who pays for the sites to be cleaned up?

a. Organizations and people responsible for contamination at the sites.
b. EPA through the Superfund trust fund, if responsible parties cannot be identified or cannot perform the cleanup.
c. The public through a sales tax.
d. Federal agencies, such as the U.S. Department of Energy, that are responsible for site contamination.

Warm-Up 3

The Numbers Game



Duration	1 class period
Grade Level	10-12
Key Terms/ Concepts	Concentration Contaminants Toxic Unit of Measure
Suggested Subjects	Mathematics

Purpose

Students gain an appreciation for the part-per-million and part-per-billion units used to measure contaminant concentrations in the environment. Students learn to calculate these ratios and analyze a sample chemical spill to determine if cleanup action is necessary.

Background

Some toxic substances are dangerous even in very small amounts. "Part-per-million" (ppm) and "part-per-billion" (ppb) are the units of measure scientists use to describe the concentration of a hazardous substance or contaminant found within a large volume of another substance. For instance, your could find 500 ppm of a pesticide in a lake.

Expressing the amount of contamination in ppm or ppb is measuring the concentration of the substance. This way, a scientist can take a relatively small sample of water, from the lake in our example, and measure the concentration of one or more contaminants in that sample, then assume that the concentration is the same in the whole lake without testing the entire lake.

For more information on the science of detecting and measuring contamination, see the Suggested Reading list found at the end of the Haz-Ed materials. Other Haz-Ed materials that are related to this topic include *Activity 7: Identifying Risks at a Superfund Site* and *Activity 9: Making Decisions About Hazardous Waste Cleanup.*

Preparation

1. Gather the following materials:

   - Copies for each student of the Student Worksheet, *The Numbers Game. (An answer sheet for your use is included at the end of this lesson.)*

Procedure

1. Hand out the Student Worksheet, *The Numbers Game*, and have the students take the quiz in Part A. Part A is intended to gauge the students' intuitive grasp of how small a "part per million" and a "part per billion" are. Instruct the students to guess if necessary to answer these three questions. They will actually calculate the correct answers in Part B.

2. After they have completed the quiz, go on to Part B. Work with them to calculate each answer choice and, from that information, determine the correct answers to the quiz in Part A.

3. Finally, work through the Lake Jasmine spill scenario in Part C with the students.

Instructor's Answer Key

Warm-Up 3: The Numbers Game

Correct answers are boxed.

Part A

Just how small is a part per million? A part per billion? Answer the following three questions based on your "gut reaction." Guess if you need to.

1. One part per million is equivalent to **1 minute** in
   a. 1 day | b. 2 years | c. 6 weeks

2. One part per billion is equivalent to **1 second** in
   a. 3 weeks b. 17 months | c. 32 years |

Part B

Now go back and calculate each of the answers you chose in Part A. Use the procedure below for each calculation.

To calculate the relationship between 2 quantities, first **convert both quantities to the same unit of measure.** For example, to compare years to seconds, convert the years to seconds. To do this, convert the years to days, then the days to hours, the hours to minutes and the minutes to seconds:

$$\frac{365\text{ days}}{1\text{ year}} \times \frac{24\text{ hours}}{1\text{ day}} = \frac{8{,}760\text{ hours}}{1\text{ year}}$$

$$\frac{8{,}760\text{ hours}}{1\text{ year}} \times \frac{60\text{ minutes}}{1\text{ hour}} = \frac{525{,}600\text{ minutes}}{1\text{ year}}$$

$$\frac{525{,}600\text{ minutes}}{1\text{ year}} \times \frac{60\text{ seconds}}{1\text{ minute}} = \frac{31{,}536{,}000\text{ seconds}}{1\text{ year}}$$

1. Use the space below to calculate (a) 1 minute per day, (b) 1 minute per 2 years, and (c) 1 minute per 6 weeks to find the answer to question 1 of Part A. After you have completed the conversion to the same units (e.g., expressing hours, days, or weeks in minutes or seconds), you may have to round your answers to the nearest thousand, million, or billion.

a) $$\frac{1\text{ minute}}{1\text{ day}} \times \frac{1\text{ day}}{24\text{ hours}} \times \frac{1\text{ hour}}{60\text{ minutes}} = \frac{1\text{ minute}}{1{,}440\text{ minutes}} \approx \frac{1}{1{,}500} \Rightarrow \text{1 part per 1,500}$$

b) $$\frac{1\text{ minute}}{2\text{ years}} \times \frac{1\text{ year}}{365\text{ days}} \times \frac{1\text{ day}}{24\text{ hours}} \times \frac{1\text{ hour}}{60\text{ minutes}} = \frac{1\text{ minute}}{1{,}051{,}200\text{ minutes}} \approx \frac{1}{1{,}000{,}000} \Rightarrow \text{1 part per million}$$

c) $$\frac{1\text{ minute}}{6\text{ weeks}} \times \frac{1\text{ week}}{7\text{ days}} \times \frac{1\text{ day}}{24\text{ hours}} \times \frac{1\text{ hour}}{60\text{ minutes}} = \frac{1\text{ minute}}{60{,}480\text{ minutes}} \approx \frac{1}{60{,}000} \Rightarrow \text{1 part per 60,000}$$

2. Use the space below to calculate (a) 1 second per 3 weeks, (b) 1 second per 17 years, and (c) 1 second per 32 years to find the answer to question 2 of Part A.

1) $$\frac{1\text{ second}}{3\text{ weeks}} \times \frac{1\text{ week}}{7\text{ days}} \times \frac{1\text{ day}}{24\text{ hours}} = \frac{1\text{ hour}}{60\text{ minutes}} \times \frac{1\text{ minute}}{60\text{ seconds}} = \frac{1\text{ second}}{18{,}144{,}400\text{ seconds}}$$

$$\approx \frac{1}{18{,}000{,}000} \Rightarrow \text{1 part per 18 million}$$

2) $$\frac{1\text{ second}}{17\text{ years}} \times \frac{1\text{ year}}{365\text{ days}} \times \frac{1\text{ day}}{24\text{ hours}} = \frac{1\text{ hour}}{3{,}600\text{ seconds}} = \frac{1\text{ second}}{536{,}112{,}000\text{ seconds}}$$

$$\approx \frac{1}{500{,}000{,}000} \Rightarrow \text{1 part per 500,000,000}$$

3) $$\frac{1\text{ second}}{32\text{ years}} \times \frac{1\text{ year}}{365\text{ days}} \times \frac{1\text{ day}}{24\text{ hours}} = \frac{1\text{ hour}}{3{,}600\text{ seconds}} = \frac{1\text{ second}}{1{,}009{,}152{,}000\text{ seconds}}$$

$$\approx \frac{1}{1{,}000{,}000{,}000} \Rightarrow \text{1 part per billion}$$

Part C

If the conversion of units leads to a fraction with a numerator other than 1, a different method can be used to determine parts per million or parts per billion. Be sure your fraction has a smaller number on top and larger number on the bottom and divide.

To express the decimal answer in parts per <u>million</u>, move the decimal point <u>6</u> places to the right. To express the answer in parts per <u>billion</u>, move the decimal point <u>9</u> places to the right.

Example 1: $$\frac{20 \text{ ounces}}{100 \text{ pounds}} = \frac{2 \text{ ounces}}{(100 \times 16 \text{ ounces})} = \frac{2 \text{ ounces}}{1{,}600 \text{ ounces}} \approx \frac{2}{1{,}600} \Rightarrow 0.00125$$

Moving the decimal place 6 places to the right gives 1,250 parts per million. Moving the decimal place 9 places to the right gives 1,250,000 parts per billion. (You would probably not see a number this large expressed in parts per <u>b</u>illion. It is better expressed as a smaller number of parts per <u>m</u>illion.)

Example 2: $$\frac{11 \text{ ounces}}{10 \text{ tons}} = \frac{11 \text{ ounces}}{20{,}000 \text{ pounds}} = \frac{11 \text{ ounces}}{(20{,}000 \times 16) \text{ ounces}} = \frac{11 \text{ ounces}}{320{,}000 \text{ ounces}} \Rightarrow 0.00003437$$

Moving the decimal place 6 places to the right gives 34.37, or about 34.4 parts per million. Moving the decimal place 9 places to the right gives 34,370, or about 34,000 parts per billion.

(NOTE: Depending on the skill level of your class, you may need to let students practice calculating and converting measures of volume. Since students may associate volume with rectangular objects, you may want to use a swimming pool for this sample problem. Assume that a 50-gallon container of chlorine is spilled into a swimming pool, which is 100 feet long by 50 feet wide by 10 feet deep.)

Based on the scenario described below and the table of legally allowable concentrations of contaminants in surface water, decide whether local public health officials should take measures to keep vacationers near Lake Jasmine out of the water.

Allowable Quantities:	Fuel Oil A	2.2 ppm in recreational waters
(concentrations of contaminants	Pesticide B	4.7 ppm in recreational waters
above these levels require action)	Solvent C	1.3 ppm in recreational waters

Conversion Table: 1 acre = 43,560 square feet
1 gallon = 0.1337 cubic feet
1 cubic foot = 7.48 gallons

SCENARIO

Lake Jasmine is a 20-acre lake with an average depth of 30 feet. Yesterday afternoon, four 55-gallon drums of Fuel Oil A and six 55-gallon drums of Solvent C fell off a truck during an accident, rolled into Lake Jasmine and burst open on the rocky shore. The entire contents of all the drums spilled into the lake.

STEP 1

Calculate the concentration of each contaminant (in ppm) in Lake Jasmine. To do this you must compare the volume of the contaminants (gallons) to the volume of the lake (cubic feet).

Start by converting both to cubic feet. To calculate the volume of the lake, multiply the area (in square feet) by the depth (in feet) to get cubic feet.

Calculate volume of contaminants:

4 x 55 gallons Fuel Oil A x 1 cubic foot/7.48 gallons = 29.42 cubic feet Fuel Oil A
and
6 x 55 gallons Solvent C x 1 cubic foot/7.48 gallons = 44.12 cubic feet of Solvent C

Calculate volume of Lake Jasmine:

20 acres x 30 feet x 43,560 square feet/acre = 26,136,000 cubic feet of water in Lake Jasmine

Comparison:

29.42 cubic feet Fuel Oil A/26,136,000 cubic feet Lake Jasmine
= 29.42/26,136,000
= 0.0000011
Moving the decimal point 6 places to the right gives <u>1.1 ppm Fuel Oil A</u>

44.12 cubic feet Solvent C/26,136,000 cubic feet Lake Jasmine
= 44.12/26,136,000
= 0.0000016
Moving the decimal point 6 places to the right gives <u>1.6 ppm Solvent C</u>

STEP 2

Compare these levels to the values in the chart of allowable quantities to see if they exceed the legally allowable levels.

Allowable Quantities: *(concentrations of contaminants above these levels require action)*

Fuel Oil A	*2.2 ppm in recreational waters*
Pesticide B	*4.7 ppm in recreational waters*
Solvent C	*1.3 ppm in recreational waters*

1.1 ppm Fuel Oil A does not exceed the allowable concentration of 2.2 ppm. If that were the only chemical spilled, no action would be necessary.

However, since 1.6 ppm Solvent C does exceed the limit, local health officials will have to keep Lake Jasmine residents out of the water until the levels of contaminants are lowered.

The Numbers Game

Part A

Just how small is a part per million? A part per billion? Answer the following three questions based on your "gut reaction." Guess if you need to.

1. One part per million is equivalent to **1 minute** in
   a. 1 day   b. 2 years   c. 6 weeks

2. One part per billion is equivalent to **1 second** in
   a. 3 weeks   b. 17 months   c. 32 years

Part B

Now go back and calculate each of the answers you chose in Part A. Use the procedure below for each calculation.

To calculate the relationship between 2 quantities, first **convert both quantities to the same unit of measure.** For example, to compare years to seconds, convert the years to seconds. To do this, convert the years to days, then the days to hours, the hours to minutes, and the minutes to seconds:

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After you have completed the conversion to the same units (e.g., expressing hours, days, or weeks in minutes or seconds), you may have to round your answer to the nearest thousand, million, or billion.

Use the space below to calculate (a) 1 second per 3 weeks, (b) 1 second per 17 years, and (c) 1 second per 32 years to find the answer to question 2 of Part A.

Part C

If the conversion of units leads to a fraction with a numerator other than 1, a different method can be used to determine parts per million or parts per billion. Be sure your fraction has a smaller number on top and larger number on the bottom, and divide.

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Example 1: $$\frac{\text{20 ounces}}{\text{100 pounds}} = \frac{\text{2 ounces}}{\text{(100 x 16 ounces)}} = \frac{\text{2 ounces}}{\text{1,600 ounces}} \approx \frac{2}{1{,}600} \Rightarrow$$

Moving the decimal place 6 places to the right gives 1,250 parts per million.
Moving the decimal place 9 places to the right gives 1,250,000 parts per billion.

(You would probably not see a number this large expressed in parts per <u>b</u>illion. It is better expressed as a smaller number of parts per <u>m</u>illion.)

Example 2: $$\frac{\text{11 ounces}}{\text{10 tons}} = \frac{\text{11 ounces}}{\text{20,000 pounds}} = \frac{\text{11 ounces}}{\text{(20,000 x 16) ounces}} = \frac{\text{11 ounces}}{\text{320,000 ounces}} \Rightarrow 0.00003437$$

Moving the decimal place 6 places to the right gives 34.37, or about 34.4 parts per million. Moving the decimal place 9 places to the right gives 34,370, or about 34,000 parts per billion.

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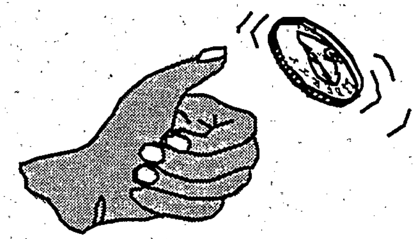
STEP 1
Calculate the concentration of each contaminant (in ppm) in Lake Jasmine. To do this you must compare the volume of the contaminants (gallons) to the volume of the lake (cubic feet).

Start by converting both to cubic feet. To calculate the volume of the lake, multiply the area (in square feet) by the depth (in feet) to get cubic feet.

STEP 2
Compare these levels to the values in the chart of allowable quantities to see if they exceed the legally allowable levels.

Warm-Up 4

Risk Concepts



Duration	1 class period
Grade Level	7-10
Key Terms/ Concepts	Environmental Risk Risk Probability
Suggested Subjects	Biology Chemistry Creative Writing English Life Science Physical Science Mathematics

Purpose

In this exercise, students explore the meaning of risk in terms of a simple exercise in probability. They explore the idea that not all risks have the same consequences and are not likely to occur at the same rate. The exercise helps students to evaluate the impact of risk on the basis of probabilities, benefits, and their perceptions.

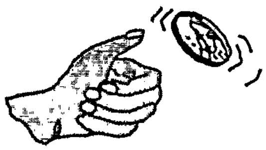
Background

Nothing in life is a "sure thing." While it is unlikely that it will snow in Texas in April, it is possible. In the same way, it is unlikely that it will be 80 degrees in Massachusetts in December, but it is possible. Saying something is "unlikely" or that it "probably will happen" is an indication of the **probability** that this particular thing will occur. Every day you weigh probabilities even without realizing it.

For example, when you take a test, you think about the chances of getting an "A." How likely you think it is that you'll get an "A" depends on how well you studied and how hard you think the test will be. Or, if you want to be picked for a team, the chances that you'll make it depends on how many other people want to play and how good you are in comparison to everyone else.

When it comes to the environment, the chance of something dangerous happening is called **risk.** Each type of hazardous substance, hazardous waste, or dangerous situation involves a different amount of risk. The risk is made up of two parts: (1) the chance that people will be exposed to the substance, and (2) the chance that exposure will injure or harm them. **Environmental risk** measures the probability that the environment will be damaged by a particular hazardous situation. Decisions on cleaning up a Superfund site are based on the risks the site poses to people and the environment.

There are generally many factors involved in determining the risks surrounding a particular hazardous situation. These factors include the potential for damage each particular substance can cause, the chances that the substance is going to spread from the original site through water, wind, or some other means, and the chance that people will come in contact with the substance.



In this Warm-up, students perform a simple exercise in probability to gain a beginning understanding of how chance operates. For additional information on probability, and risk, and environmental risk assessment, see the Suggested Reading list found at the end of the Haz-Ed materials. Other Haz-Ed materials that are related to this topic include *Activity 7: Identifying Risks at a Superfund Site* and *Activity 9: Making Decisions about Hazardous Waste Cleanup.*

Preparation

1. Gather the following materials:

   - Several coins
   - Several sheets of paper
   - Several pencils
   - Copies for each student of the Student Worksheet, *Risks and Benefits.*

Procedure

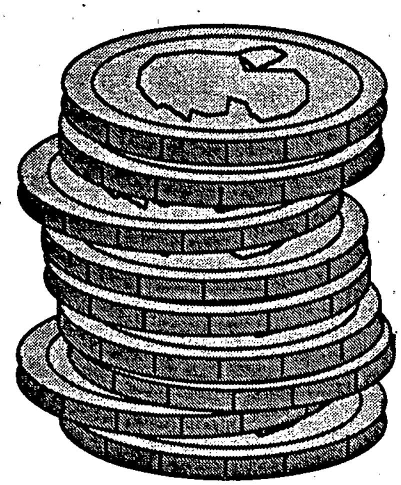
1. Explain to students that the class is going to conduct an exercise in probability by tossing a coin. Explain that, for one brief moment, when a coin is tossed into the air, it assumes a state of unpredictability. We know that it will either be heads or tails, but we cannot know which one while the coin is in the air. Even so, in repeated trials under similar conditions, we do know that heads will come up half the time and tails the other half. This illustrates the theory of probability—how likely it is that a particular result will occur in a given situation.

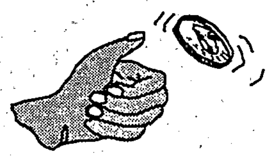
2. Organize the class into groups of about 2 or 3 students each. Give each group a penny, a piece of paper, and a pencil. If necessary, demonstrate how to toss a coin to determine heads or tails.

3. Instruct each group to flip the coin 50 times, recording the results of each toss. Have the students record the total number of heads and total number of tails that occurred after:

   - 5 coin flips
   - 10 coin flips
   - 25 coin flips
   - 50 coin flips.

   Record each group's results on the chalkboard.





4. Explain that few events are as predictable as a coin toss. No matter how many times a coin comes up heads, there is only a 50-50 chance that the next toss will be tails. While the ratio of heads to tails may vary with only a few repetitions, the ratio stabilizes at or near one-half after many repetitions. (For example, theoretically it would take a million people tossing coins 10 times a minute 40 hours a week for 9 centuries for a coin to fall on heads 50 consecutive times.)

5. Have the class compare the results of the coin toss exercise for each group. Did the ratio of heads to tails vary after 5 tosses? After 10 tosses? Was the final ratio about one-half? If not, why?

6. Explain that although the coin toss demonstrates the fundamental principle of probability, determining the risks of injury, disease, or death from a particular hazard is far more complex. This is true mainly because these risks are dependent on the occurrence of other factors, and the interaction of multiple factors, such as contact (or exposure) to the hazard that causes the effect.

7. Distribute a copy of the Student Worksheet, *Risks and Benefits,* to each student and review the instructions for both parts. Give students about 10 minutes to complete the worksheet (individually or in small groups). Have students discuss their answers to the questions.

Extensions (Optional)

- Assign students to go to the library and look up details to support the answers they gave in Part B of the worksheet (for example, what gasoline is made of and why it is harmful, the number of automobile or airplane accidents that occur each year, or where PCBs come from).

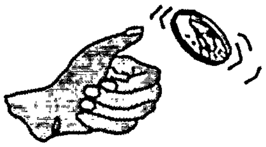
- Have the students write a short story about how one of the risks listed in the work sheet was harmful to people or the environment. This may require students to conduct some research. The resources in the Suggested Reading list are helpful. Allow the students to base their story on a true event if they wish. Select the best stories, and ask the students who wrote them to summarize them for the class. Discuss the stories in terms of the students' personal willingness to accept voluntary and involuntary risks.

Risks and Benefits

Part A

For each situation listed below, describe a potential danger (something that could happen that would cause concern for public health). List at least two ways people or the environment could be injured and, if possible, at least one benefit that people or the environment could gain from it.

- Transportation of a hazardous substance on highways near urban areas (see example on second page)
- An old municipal and industrial dump that does not meet current design and safety standards
- A large housing area built on an unknown hazardous waste site contaminated with polychlorinated biphenyls (PCBs)
- Storage of gasoline in underground tanks at local gas stations
- Travel by automobile
- Travel by airplane
- Cigarette smoke
- Pesticides
- A tornado



EXAMPLE: Transportation of a hazardous substance like mercury on highways in urban areas

What Could Happen: A traffic accident causes the container to rupture and release mercury into a lake or stream.

Injury: Mercury builds up (bioaccumulates) in the fish, which people and wildlife eat, and threatens the public water supply serving many people downstream. People and wildlife may become ill, some may die, and offspring suffer severe birth defects.

Benefit: Mercury is used in manufacturing many important products, including paint and paper and in processing leather. It is a key element in dental fillings, thermometers, and some fungicides and insecticides.

Part B

Now, answer the following questions:

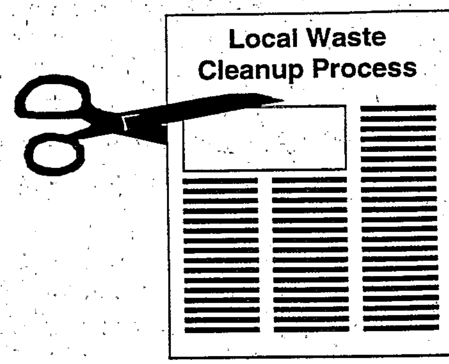
1. How would you rank the situations in Part A in terms of how risky they are and how likely injuries are to happen?

2. How would you rank the risks in terms of the number of people affected and the severity of the possible harm? (That is, which situations present the deadliest and most widespread risk?)

3. Which of the risks are you willing to accept (voluntarily), and which do you <u>have</u> to accept (involuntarily)? (For example, you can choose not to smoke cigarettes but you may not be able to prevent the transportation of hazardous substances along a highway near where you live.)

Warm-Up 5

Hazardous Waste Issues in the News



Duration	1 1/4 class period
Grade Level	7-12
Key Terms/ Concepts	Contamination Hazardous waste
Suggested Subjects	Chemistry Geography History Life Science Physical Science Social Studies Journalism

Purpose

In this exercise, students conduct research to collect reports in newspapers or on TV or the radio on local and national hazardous waste issues. This helps students appreciate the magnitude of the hazardous waste problem. A follow-up discussion allows students to explore how hazardous waste issues affect their community.

Background

The news media—newspapers, news magazines, television and radio stations—informs people about environmental issues and problems. News reports can play an important role in shaping the public's perceptions of the government's efforts to address the issues and resolve the problems. For example, the media not only reports on environment-related events, such as accidents involving the release of hazardous materials or the discovery of hazardous waste **contamination** at a site; it also lets people know how officials are responding and, if necessary, what to do to protect themselves from the hazards involved. The media also helps to keep people informed about the day-to-day progress of **hazardous waste** cleanup efforts, recycling programs, and efforts to conserve natural resources.

The way reports are written can give a good or bad impression of what is being done to remedy hazardous situations. The media can also help communities focus on potentially dangerous situations so prevention measures can be taken before the site becomes truly hazardous.

For additional information on the role the media plays in environmental protection and cleanup, see the Suggested Reading list found at the end of the Haz-Ed materials. Other Haz-Ed materials that are related to this topic include *Fact Flash 10: Superfund Community Involvement Program.*

Preparation

1. Gather the following materials:

    - Copies for each student of the following Student Handouts, which present sample articles.

Procedure

Class #1

1. Discuss the role of the media in relationship to Superfund. The media is how most people learn about hazardous waste issues.

2. Explain to students that a follow-up class (specify the date) will focus on the problem of hazardous waste. To prepare for the class, they are to gather reports from the news media (newspapers, magazines, radio, and television) about hazardous waste sites and other environmental contamination problems. Distribute the attached Student Handouts, which can serve as examples of the kinds of stories to look for.

3. Divide the students into 6 teams. Assign each team one of the following:

    a. Collect articles from local newspapers

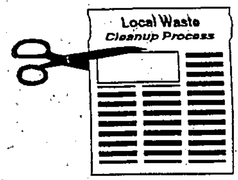
    b. Collect articles from national newspapers (New York *Times*, Washington *Post*, Los Angeles *Times*) or from major daily newspapers in your state

    c. Collect articles from national news magazines (*Newsweek*, *Time*, *U.S. News and World Report*) or environment-related magazines (*Ecology*, *Audubon*, *Science*)

    d. Monitor and take notes on radio programs (all-news stations, National Public Radio, and local radio "public affairs" programs)

    e. Monitor and take notes on television news programs—daily local news, daily national (network) news, CNN, weekly news programs such as *60 Minutes* (CBS), *Dateline* (NBC), *Prime Time Live* (ABC)

    f. Gather information from the local library on hazardous waste problems and toxic contamination of soil and water since 1980. *(This information should include, but not be limited to, reports on Love Canal near Niagara Falls, New*



York; Times Beach, Missouri; and the 1980 explosion and fire at the Chemical Control Company in Elizabeth, New Jersey. The problems in these communities are referenced in many books about hazardous waste and pollution—see Suggested Reading list.)

4. Stress that teams with assignments a-e should focus on collecting information about hazardous waste problems in their local area or their state; articles about those in other parts of the country should be gathered only if no local-interest stories are available. They should gather information on the kind of waste, type of incident, location of incident, and people responsible.

5. Allow each team to organize itself and make individual assignments to avoid duplication of effort and complete the research needed. Suggest that each team select a spokesperson to present a brief summary of the information collected by the team at the beginning of the follow-up class.

6. Give teams 3 weeks to conduct research.

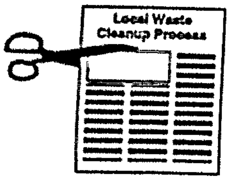
Class #2

1. Have team members sit together for this class. Have the spokesperson for each team summarize the information the team has collected. Following the presentations, have the class discuss the information presented. Encourage students to compare various hazardous waste issues and problems highlighted in the presentations, what caused them, how they were discovered, and how they are being (or were) addressed.

2. Ask students what conclusions they can draw from this information about how hazardous waste might affect their community. Have them suggest ways they can prevent or minimize the potential problems related to hazardous waste.

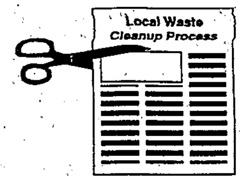
Extensions (Optional)

- Have the students write an article or an editorial for your school or community newspaper or a local radio or television station highlighting hazardous waste issues in your community (or state). Have them research how to prepare the material for submission, who to send it to, and how to follow-up to ensure the best chance of publication or broadcast. Have students share their articles and editorials with the class. Encourage one or more students to pursue publication or broadcast of their material and to share the results with the class.



- Have students make a collage of articles they collect and display it on a school bulletin board or use it as the backdrop for a presentation on hazardous waste issues to a school assembly.

- Have students set up an information booth in the school on Earth Day or another environmental event. They can collect and distribute the information they gathered for this assignment and inform other students of hazardous waste sites in the area.



Tank Farm Pollution May Originate from Up to 7 points, Officials Say

By Mike Ward

As many as seven plumes of contamination may be responsible for the underground pollution around East Austin's gasoline tank farm, Texas Water Commission officials said Friday.

At least two of the plumes, they said, may be caused by leaking underground fuel tanks not associated with the tank farm.

"We think we have the plumes pretty well defined now, and we are pressing ahead to clean up the soil and water contamination," said Ken Ramirez, the commission's deputy director.

Agency specialists said they are not planning to require the removal of the contaminated soils as part of that cleanup.

"We haven't ruled it out, but we haven't ruled it in, either," said David Ruckman, who is overseeing the cleanup for the agency. "You'd be talking about a major project to remove soil, and we'd like to avoid that if possible. Plus, what you'd be doing is picking up the contaminated soil one place and moving it to another place."

Ruckman said a string of test wells around the six fuel terminals, which are on a 52-acre site at Springdale Road and Airport Boulevard, show one plume of tainted groundwater beneath the Chevron site.

That plume, likely resulting from a 1987 spill of more than 12,500 gallons of gasoline, apparently has seeped beneath the neighboring Exxon terminal, he said.

A second plume apparently lies under the adjacent Mobil and Star Enterprise terminals, just to the south, according to Ruckman. He said Star may have a separate contamination plume on another portion of its property and is running additional tests.

A fourth plume, he said, emanates from the Coastal States terminal on Jain Lane. And a fifth plume extends from the site of a 1988 pipeline break at the edge of the neighboring Citgo terminal.

Groundwater contamination has also been found beneath a Kraft Foods plant, across Airport Boulevard from the Star Enterprise terminal, according to Water Commission officials. That apparently resulted from a leaking underground tank and is to be cleaned up, they said.

"There may be another plume beneath the area of Airport and Bolm (Road), but at this point we're not sure whether it's coming from Citgo" or a Payless gas station-convenience store at that intersection, he said.

When the controversy over underground pollution at the fuel terminals began five months ago, officials speculated that contamination resulted from two and possibly three plumes. Additional test wells and monitoring work by experts led to the additional details, Ramirez said.

Ruckman and Robin Shaver with Water Commission's underground storage tank unit said several of the six oil companies that operate the fuel terminals are being asked to drill additional test wells to provide a better definition of the plumes. Most of that work will take place south of the Coastal and Citgo terminals, they said.

"We're at the point where we think we've got a good handle on where the plumes are and where we don't need to do a lot more tests as an agency," Ruckman said. "We're now getting the oil companies to take the ball on this—get things cleaned up."

As part of the cleanup, several oil companies have proposed pumping out contaminated groundwater and cleansing it of gasoline contaminants that have seeped underground. But removal of contaminated soil, sought by neighborhood residents to prevent recontamination, is not among those plans at present, officials said.

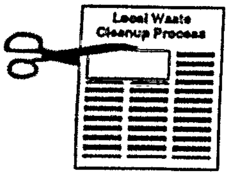
"We have not established any exposure risk to humans" from leaving the tainted soil in place, Shaver said. "It's 20 feet below the surface. There shouldn't be any danger."

Nonetheless, Ramirez and Ruckman said soil removal—which would make a cleanup much more expensive and could force relocation of some residents—has not been ruled out as an option. Ramirez said monitoring wells could be used to check any future pollution, once groundwater steps are complete.

Neighborhood leaders said they want the soil cleaned up.

"The oil companies must clean up what they messed up," said Ron Davis, who heads the East Austin Strategy Team, a coalition of community groups. "They need to clean it up at their expense. And if the Water Commission does not want to execute the will of the people, they should step aside."

***American-Statesman*, June 27, 1992, Austin, Texas**



3 Firms Ante Up Share of the Bill To Cleanse Toxic Site in Newark

By Bill Ganno

Three companies have agreed to pay part of the Federal government's $22 million cleanup of the White Chemical Corp. Superfund site in Newark, the Environmental Protection Agency (EPA) announced yesterday.

According to the terms of a Superfund unilateral order issued by the EPA late last month, Monsanto Co., Inc., PPG Industries, Inc. and Rhone Poulenc AG Co. have agreed to share in the costs of the cleanup.

But the owner of the 4.4 acre site, the bankrupt operator of the plant and five hazardous waste generators have all refused to help pay for the cleanup and may be targets for future legal action, EPA officials noted.

The company manufactured acid chlorides and flame retardant compounds used by agricultural, pharmaceutical and building products industries at its Frelinghuysen Avenue plant.

The EPA took control of the site in August 1990, several months after a raid on the plant by State investigators from the Attorney General's Office and the Department of Environmental Protection and Energy (DEPE).

At the time of the raid, shocked DEPE investigators found more than 11,000 drums of hazardous materials strewn around the property. Also found were thousands of deteriorating laboratory containers, gas cylinders and improperly stored chemicals.

The conditions at the facility were so dangerous that the Agency for Toxic Substances and Disease Registry warned that the site and the cleanup process could create hazards such as vapor releases, fires, or even explosions.

The site, officials said at the time of the raid, posed a serious health risk to the neighborhood of some 12,000 residents who live within a half mile of the plant.

Located less than a mile from Weequahic Park, Newark International Airport, the Anheuser-Busch brewery as well as several manufacturing facilities and hotels, office buildings and businesses along nearby busy Routes 1 and 9, members of the Newark and Elizabeth city council say the site has been an environmental nightmare waiting to happen.

DEPE inspectors found that White's improper management of stored toxic and hazardous material had resulted in numerous open containers, frequent releases of hazardous chemicals, damaged, bulging, unlabeled containers, numerous spills and incompatible materials being improperly stored together.

The site was proposed for inclusion on the Superfund national priorities list in a special update in May 1990 and finalized on Sept. 25, 1991. Superfund is the Federal program to clean up abandoned or inactive hazardous waste sites.

So far, the Federal agency has spent more than $10.5 million on the removal of thousands of drums and other containers of hazardous materials from the White property. Before EPA took control of the site, DEPE spent more than $825,000 in cleanup costs.

The EPA has inventoried and sampled approximately 7-900 drums and 110 tank vessels as well as categorized and separated over 12,500 lab containers, officials said yesterday.

Of the 11,600 drums found on site, 4,000 empty containers were cleaned and sent away for recycling. EPA has also recycled 48,000 pounds of solid materials and 36,000 gallons of liquid materials.

More than 50 gas cylinders have been returned to the original manufacturers while some 60,000 gallons of liquid wastes, including acids from 1,700 drums, have been drained and stored in tanks on site.

"To date, as a result of regional enforcement efforts, private parties have contributed approximately $500 million in Superfund settlements in New Jersey," EPA Administrator William Reilly said in a prepared statement issued by the agency.

"The Superfund emergency removal program used fast-track hazardous waste cleanup methods to stabilize the White Chemical site," Reilly said.

White Chemical moved to Newark in 1983, leaving behind another polluted tract in Bayonne. DEPE had cited the company in 1979 for violations, including unlawful storage of hazardous waste.

The Bayonne site is now also under consideration for possible inclusion on the Superfund list, according to State environmental prosecutor, Assistant Attorney General Steven Madonna.

Madonna initiated a probe of the plant that lead to the indictment of the firm and its owner, James White, by a grand jury.

In a May 7 plea bargain agreement with Madonna's office, White, 68, pleaded guilty in Superior Court in Newark to two counts of the five count indictment, admitting he illegally stored and disposed of more than 2,000 drums of dangerous chemicals at his plant.

As part of the plea, the State will recommend White serve at least 364 days in jail, serve five years probation and be sentenced to 2,000 hours of community service upon his release from jail.

The conviction on the two counts of unlawful storage and disposal are both third-degree crimes and carry potential sentences of between three and five years and a fine of up to $7,500. Sentencing before Superior Court Judge Richard Newman in Newark is scheduled for June 22.

***Star-Ledger*, June 5, 1992,**
Newark, New Jersey

"Super" News

Saegertown Superfund Site Cleanup Gets a "Cleaner" Plan

By Judy Acker

Changes have been approved for proposed cleanup of the Saegertown Superfund site, eliminating the need for on-site incineration of toxic soil.

Both the Environmental Protection Agency and GATX Corp., former owners of the industrial area, have OK'd a new, cheaper cleanup plan which could save GATX as much as $7 million and cut down on dust and smoke generated by the incineration process.

The 100-acre area, on the southeast side of Saegertown along Route 198, was the site of a former GATX repair facility for railroad tank cars, in operation from 1951 to 1967.

EPA placed the site on the Superfund cleanup list in 1990 after finding soil and groundwater were contaminated by toxic waste products.

GATX, now headquartered in Chicago, is a management business for acid-based transportation. The firm leases railroad tank cars and offers full service including repair and maintenance of the cars.

Caren Arnstein of ENSR Consulting and Engineering—contracted by GATX to design and oversee the on-site cleanup operation—said GATX submitted a formal request to EPA on Jan. 9 to modify the cleanup plans.

Originally, cleanup was to be done by a mobile incinerator. GATX now has asked EPA to allow for off-site treatment.

The plan provides GATX would excavate the contaminated soils and materials and ship them to existing facilities for treatment. Soil contaminated by heavy tars would be shipped to Wampum, south of New Castle, and other contaminated soils would be sent to either Kansas or South Carolina to be detoxified.

GATX said the alternative plan would be faster, less expensive and just as safe as on-site incineration. In addition, the plan provides a use for the materials excavated at the site through energy recovery and materials recycling.

EPA will prepare an "Explanation of Significant Difference" required as part of the Superfund process. The new proposal is expected to meet no resistance from Superfund officials.

GATX has retained ENSR and other experienced environmental contractors to conduct excavation and cleanup.

"This change will benefit the Saegertown community because it will eliminate the need for an on-site incinerator, and will result in faster completion of on-site activities," said Jay Grove, GATX senior environmental engineer.

"We share the borough's concerns about remediating the site as quickly and as safely as possible, so the land may be developed for productive use," he said.

Grove said the new plan is as safe or safer than the previous one for the residents of Saegertown, because it complies with all State and Federal regulations and won't require new permits.

Steve Donohue of EPA said the proposal is justifiable for several reasons: it's faster, the waste will be treated as effectively with resource conservation now possible, and cost would be reduced to half of the estimated $14 million proposed in the original plan.

With the new plan, the estimated completion date for remediation is February 1996.

Donohue will be available for a public question and answer session Feb. 21 from 7 to 9 p.m. at the Saegertown Borough Building.

***Tribune*, June 27, 1995, Meadville, Pennsylvania**

Cleanup Set For Toxic Site

By Arnold Abrams

It looks like another empty lot in a scraggly industrial area, unappetizing but harmless. Lurking unseen beneath the ground on the half-acre site in Garden City, however, are chemical solvents and petroleum products that have seeped into the dirt and threaten to contaminate public drinking water.

That much was determined more than a decade ago by Nassau County and Hempstead Town authorities, who ran a series of tests and then filed formal complaints against the Pasley Solvents and Chemicals Co., which had used the site as a chemical distribution facility since 1969.

Pasley declared bankruptcy soon after the county and State acted, but nothing was done to the site. By June 1986, it had been designated as one of Long Island's worst hazardous waste sites. It also had been placed on the Federal Environmental Protection Agency's national list of Superfund sites requiring remedial action.

Such action now is about to begin at the Pasley site.

News about the project came last month, when EPA officials announced that approximately $14 million will be spent to remove waste and eliminate hazards at the site.

***Newsday*, June 15, 1992, Garden City, New York**

EPA To Begin Glen Ridge Cleanup; W. Orange Radium Work Continues

By Caryl R. Lucas

The U.S. Environmental Protection Agency (EPA) this week will make way for the excavation of radium-contaminated soil from seven homes in Glen Ridge, as a cleanup project moves forward in West Orange.

Pat Seppi, an EPA spokeswoman, said yesterday the Federal agency was able to move up its Superfund cleanup project in Glen Ridge because excavation of radium-contaminated soil from 15 homes in West Orange is going well.

Project coordinator Romona Pezzelli said the agency had been scheduled to begin the cleanup at the seven homes on Carteret Street in the fall. The cleanup also will include a contaminated section of Carteret Park, where the EPA has set up trailers on a portion of the playground.

"In West Orange, eight homes have been completed," said Seppi. In February, the agency began excavating tainted soil from properties on James Court and Alan and Maple streets in West Orange following completion of the cleanup project at 15 Montclair homes.

Seppi said two of the six West Orange families who were relocated have moved back. She anticipates all of the homes there will be restored within four months.

As part of EPA's plan to have work going on in all three communities concurrently, Seppi said the agency began its preliminary work and surveys in Glen Ridge last month.

"We expect to start driving the sheet piling this week and begin other aspects of construction," she said.

Last week, one of the Glen Ridge families whose property will be remediated was relocated temporarily, Seppi said. Two other families are expected to be relocated this week, while the remaining families will be moved by the first week of July.

Saying the majority of the Glen Ridge Properties are among the most severely contaminated homes, Seppi said the cleanup project will take up to six months.

Under a 10-year, $250 million Superfund project, the EPA will remove tainted soil from 160 properties in the three Essex County towns. In all, the Federal government discovered contaminated soil on 747 properties designated Superfund sites in Essex County.

Glen Ridge Mayor Carolyn Bourne praised the EPA officials for their cooperation on the remediation plans.

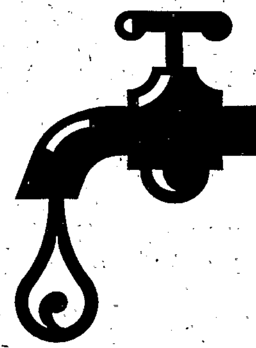
"I am pleased at this point," she said. "Things are going right on schedule."

At the request of borough officials, Bourne said the EPA reduced the amount of space it is using for its trailers and work compound. She also commended the EPA for purchasing new equipment for the park's playground.

***Star-Ledger*, June 16, 1992, Newark, New Jersey**

Warm-Up 6

What Is an Aquifer?



Duration	1 class period
Grade Level	7-9
Key Terms Concepts/	Aquifer Groundwater Porosity Saturated zone Saturation Water table
Suggested Subjects	Earth Science Physical Science

Purpose

This lesson demonstrates the meaning of the terms groundwater, porosity, aquifer, and water table*. It helps students better understand how and why water is stored underground, and what can happen if the water is drained or polluted. Students discuss the uses of groundwater in their community. They create an aquifer model and view the saturated and unsaturated zones. They also create a lake in the aquifer model and observe the connection between surface water and groundwater.

Background

Many hazardous waste sites contaminate **groundwater**, which is a major source of drinking water in the United States. Many hazardous waste accidents and sites involve hazardous substances leaking into **aquifers** and contaminating groundwater.

Cleaning up groundwater is one of the major concerns the U.S. Environmental Protection Agency (EPA) and state environmental programs have about hazardous waste sites. This warm-up exercise provides some fundamental information for understanding groundwater. It also helps prepare students for *Activity 2: Examining a Hazardous Waste Site* where a hypothetical hazardous waste site is reviewed and students build a groundwater model.

For more information on groundwater and related topics, see the Suggested Reading list found at the end of the Haz-Ed materials.

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* *Adapted from* Water Resources Professional's Outreach Notebook: Groundwater, *by Stephen J. Vandas, U.S. Geological Survey, U.S. Department of Interior. For the complete Notebook, write: U.S. Geological Survey, Earth Science Information Center, Open-file Reports Section, Box 25286, MS-517, Denver Federal Center, Denver, CO 80225.*

Preparation

1. Gather the following materials:

   - 9-oz. (266-mL) clear plastic cup (1 per group)
   - resealable plastic sandwich bag filled with 3/4 cup of pea-size gravel (1 per group)
   - 3.4-oz (100-mL) graduated cylinder (1 per group)
   - 1 small bottle of blue food coloring
   - grease pencil (1 per group)
   - 1 gallon (3.8 liters) of water
   - 3 large sponges for cleanup
   - copies for each student of *Fact Flash 5: Groundwater*

2. Read *Fact Flash 5: Groundwater* to prepare your lecture for the class.

3. Assign students to read *Fact Flash 5: Groundwater* for homework.

4. Find out the source (surface, groundwater, or a combination) of the community's drinking water supply and uses of groundwater in the community. If available, find out the depth to groundwater, the type of aquifer, aquifer thickness, areal extent of the aquifer, and **porosity** of the aquifer that makes up the groundwater system beneath the community. For this information, contact the local office of the U.S. Geological Survey.

5. Fill the resealable plastic sandwich bags (1 for each group) with enough pea-size gravel to fill the model cups approximately 3/4 full.

Procedure

1. Review Fact Flash 5 which students read as homework.

2. Ask the students if they know where the water in their community comes from. Approximately 50 percent of the nation's population receives its water from groundwater (the remainder uses surface water). Discuss uses of groundwater in the community. Inform the students of the depth to groundwater beneath their community and ask if they know what an aquifer is. If appropriate, ask how many of the students have wells at their homes. Have a student who has a well describe it.

3. Break the class into small groups and explain that each group is going to build a model of an aquifer. An aquifer is an underground rock formation composed of sand, soil, gravel, or porous rock that can store and supply groundwater to wells and springs. Generally, an aquifer provides groundwater that can be used as drinking water, or for irrigation or industrial purposes. Discuss the origin of their community's water supply. Designate one person in each group as a supply person. *(NOTE: This activity has been developed for small groups of students. Limit the number in each group to no more than 8. If this activity is to be conducted with more than one class, replace the wet materials with dry materials for each group.)*

4. Have the supply person from each group obtain 1 plastic cup, 1 resealable plastic sandwich bag containing pea-size gravel, and 1 graduated cylinder from the supplies you prepared. Have students pour the contents of the resealable plastic sandwich bag into the cup.

5. Ask students what they think will happen if they pour 30 mL of water into their group's aquifer cup model. Record responses on the chalkboard.

6. Have students pour 30 mL of water into their group's aquifer cup model and observe what happens. Compare the actual results to what the students guessed. Were they right? What were the differences? Have students pour an additional 30 mL of water into their aquifer. Inform the students that they have created an aquifer. *(NOTE: This aquifer is generic and is not intended to represent the local aquifer system.)*

7. Discuss the concept of **saturation.** Identify the **saturated zone** and the unsaturated zones in the aquifer cup model. Help students discover that the aquifer becomes saturated from the bottom of the aquifer cup model upwards.

8. Point out that the top of the saturated zone in an aquifer is the **water table**.

9. Instruct students to continue to add water until the water table is approximately a 1/2 inch (1.5 cm) below the top of the gravel. Mark the water table with the grease pencil on the outside of the cup.

10. Ask students to predict what will happen if they dig a hole in the gravel below the water table. Record responses on the chalkboard.

11. Have students dig a hole in their aquifer cup model and observe the results. Ask students what they have demonstrated. Were their prediction correct? *(Answer: a lake or a pond.)* Have students work together to determine how to make the water table higher or lower. *(Add more water or draw water out.)*

12. Discuss with the students the uses of groundwater in their area. Brainstorm ways groundwater might be polluted in the area. Have the students add 1 drop of blue food coloring to the lake of their model aquifer. Underscore the difficulty of cleaning up pollution by having the students try to flush their models of pollution by adding small amounts of water to their aquifer until the model almost overflows. Have the students pour water from their model aquifer into another container until the water level matches the mark they placed on the cup. Ask the students to look into their model aquifer to see if there is any colored water left in the aquifer.

Extension (Optional)

- Invite someone from your state or local department of environmental management or your Regional EPA Superfund Office to discuss groundwater and its contamination. (See your local telephone directory and the *This Is Superfund* brochure at the back of this package for contact information.)

ACTIVITIES

Activity 1

Waste: Where Does It Come From? Where Does It Go?

Duration	2 class periods
Grade Level	9-12
Key Terms/ Concepts	Hazardous waste
Suggested Subjects	Biology Chemistry Health Life Science Physical Science Social Studies

Purpose

In this lesson, students use a map to identify and locate potential sources of hazardous waste in their neighborhood or community. In the process, students learn what hazardous waste is and identify the potential threats it poses. Students learn that while most hazardous waste is the result of manufacturing processes, many common household products also become hazardous waste when thrown away.

Background

Our lifestyles are supported by complex industrial activities that produce vast quantities of waste. Industries that produce our clothing, cars, paper, medicines, plastics, electronic components, fertilizers, pesticides, and cosmetics—to name only a few—use and discard thousands of hazardous chemicals and other substances every year.

Add to that the thousands of tons of medical wastes—blood, syringes, and used bandages—thrown out by hospitals. Add to that millions of scrapped cars, buses and trucks. And to that add more than 195 million tons of garbage Americans discard every year. Household garbage contains not only eggshells and potato peelings but also hazardous substances like those in household cleaning products, used oil, and spent batteries. The result is a **hazardous waste** crisis. And the problem continues to grow.

People can help solve the hazardous waste problem and protect their own community. But in order to have an impact on the problem, people must first learn to identify the sources of hazardous waste in the community. With this knowledge, citizens can develop strategies to reduce the amount of hazardous waste produced and protect their community, their families, and themselves.

To help prepare your students for this activity, use *Warm-Up 1: Defining Hazardous Waste.* You can use the entire Warm-Up or simply review the main points covered. For additional introductory information on hazardous substances and hazardous waste, see the Suggested Reading list found at the end of the Haz-Ed materials.

Preparation

1. Assemble the following materials:

   - Map of the community, as detailed as possible (call the local Chamber of Commerce or town hall)
   - Red, green, and blue markers
   - Copies for each student of *Fact Flash 1: Hazardous Substances and Hazardous Waste.*

2. Read Fact Flash 1 to prepare for your lecture.

3. Distribute Fact Flash 1 and have students read it for homework.

Procedure

Class #1

1. Summarize information found in Fact Flash 1 and your research in preparing the class, including how hazardous waste sites are created from a variety of sources. Explain that in this class, students will identify potential sources of hazardous waste.

2. Place the map on an easel or hang it on a wall where students can see it. *(NOTE: If you live in a large city, it may be more appropriate to use a map of the school district or neighborhood in which the school is located rather than of the whole city.)*

3. Have students point out and **circle in green** significant landmarks such as the school, major factories, and shopping malls.

4. Review *Fact Flash 1: Hazardous Substances and Hazardous Waste* that students read for homework. Define terms and answer questions as needed.

5. Ask students to name some products they or their parents use at home that could produce hazardous waste. Students can use information from Fact Flash 1 to identify these products. *(NOTE: You may want to have one student record answers on the chalkboard.)* How do the students and their families dispose of these products after they are used? Do they participate in a recycling program? Is there a hazardous household chemicals disposal program in the community? Do their families participate? Do they know where the garbage from their house goes when it is picked up? **If so, have the students mark the landfill or other facility on the map in blue.**

6. Ask students to name other possible sources of hazardous waste in the community. *(NOTE: If necessary, prompt this discussion. Possible answers include not only large factories and petroleum refineries, but also gasoline stations, auto repair/paint and body shops, dry cleaners, hospitals, nursing homes, dental offices, medical laboratories and testing facilities, funeral homes, nurseries, garden supply stores, farms, poultry breeding and processing companies, major building construction sites, fast-food restaurants, and junkyards.)* **Have the students mark each of these sites on the map in red.**

7. Encourage students to suggest where waste from these facilities might go when it is picked up. *(Answers could include sanitary landfills, incinerators, recycling centers, and, in some communities, waste-to-energy plants.)* **Have the students mark these on the map in blue.**

8. Divide the class into 3 teams.

   - Assign one team the responsibility of gathering information outside class to help refine the map by identifying and marking other hazardous waste sources.

   - Assign the second team the responsibility of contacting the local health or environmental services department to investigate how much residential garbage is collected and disposed of each year and what the local government is doing to deal with the potential hazardous waste problems this creates (for example, how are paint thinners and pesticides handled?).

   - Assign the third team to do similar research about the amount and the handling of the community's industrial waste.

9. Explain that each team is to make a short presentation (5 to 10 minutes) on the results of their research during a follow-up class (specify the date). Allow each team to select a spokesperson to make the team's presentation and to organize itself and assign specific tasks in order to complete the project.

Class #2

1. Have each group present its research findings to the class. Encourage students to ask questions and to discuss how they, as individuals and as a class, might influence the local government's efforts to reduce the hazardous waste problem. Have a student record the ideas on the chalkboard.

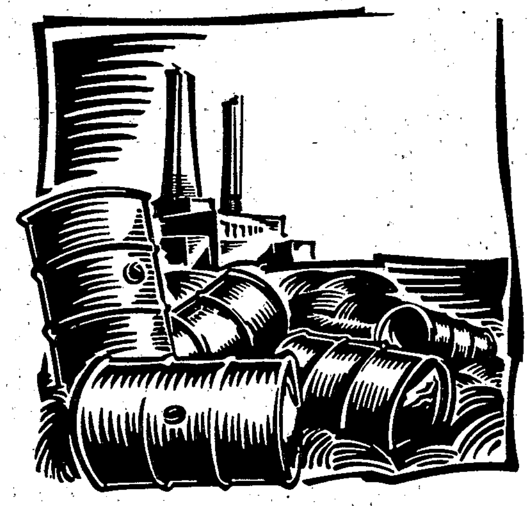
2. Ask for suggestions on how to take action on any of the ideas offered. Whom would students want to approach with their ideas? What would be the best, most effective way to present their ideas? *(NOTE: The point here is to elicit some ideas for presentation formats. The list might include writing a report on their research and making recommendations, writing an article for the school or community newspaper, designing a display and putting it in the school lobby or taking it to a local shopping mall, or making a presentation at a school assembly or at a PTA meeting.)*

Extension (Optional)

- Allow the class to choose specific ideas they want to pursue and design a plan of action. Monitor and facilitate their progress until completion.

Activity 2

Examining a Hazardous Waste Site



Duration	2 class periods
Grade Level	9-12
Key Terms/ Concepts	Aquifer Contamination Hazardous waste Superfund Water table
Suggested Subjects	Chemistry Earth Science Geology Physical Science

Purpose

This activity helps students understand how Superfund sites are created. They discuss what activities produce hazardous waste, and how contaminants are released and spread into the air, water, soil, and groundwater. Students learn what types of pollution can be cleaned up using Superfund authority and what types are addressed through other laws. Students construct a model to observe how contaminants move in groundwater.

Background

The U.S. Congress passed the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) in response to growing concern about health and environmental threats from hazardous waste sites. This law is commonly called **Superfund**. Working with states and Indian Tribal governments, Superfund requires the U.S. Environmental Protection Agency (EPA) to deal with abandoned, accidentally spilled, or illegally dumped **hazardous wastes** from the past, primarily from businesses and industry. Other types of pollution are handled by other environmental laws.

The Superfund program has a process for reporting and keeping track of potentially contaminated sites. Since the early 1980s when the law took effect, more than 37,000 hazardous waste sites have been reported. EPA must investigate each of the sites to determine the seriousness of the **contamination**. Only the most serious sites are cleaned up using Superfund authority; approximately four percent of reported sites are being cleaned up under Superfund. Sites not handled by the Superfund Program will be cleaned up by state governments or under other laws, or will require no cleanup because they pose no danger to people or the environment.

It is important to keep in mind that the Superfund Program deals only with abandoned, accidentally spilled, or illegally dumped hazardous substances. A number of other major environmental laws—such as the Resource Conservation and Recovery Act (RCRA), the Clean Water Act, the Clean Air Act, the Toxic Substances Control Act, and the Safe Drinking Water Act—were enacted to deal with other types of pollution.

To help prepare your students for this activity, use *Warm-Up 6: What is an Aquifer?* You can perform the entire Warm-Up or simply review the major points covered in it.

For more information on hazardous waste sites and cleanups, see the Suggested Reading list found at the end of the Haz-Ed materials. Other Haz-Ed materials that are related to the topic include *Warm-Up 2: EPA's Superfund Program—Overview.*

Preparation

1. Gather the following materials *(NOTE: You can split the class into 4 groups if desired and have each group do the experiment.)*

    - bottom part of a clear, plastic two-liter soda bottle
    - pump mechanism from a liquid soap dispenser
    - small piece of nylon fabric to cover the end of the pump tube
    - tape
    - resealable plastic sandwich bag with 2 cups of small pebbles or aquarium gravel (white or light-colored)
    - resealable bag with 2 cups of clean sand (white sand is best)
    - large coffee filter (round with a flat bottom, not cone-shaped)
    - clean spray bottle, the type spray window cleaner comes in
    - bottle of red food coloring
    - clear measuring cup (2-cup size)
    - copies for each student of:
      Fact Flash 1: Hazardous Substances and Hazardous Wastes
      Fact Flash 2: The Superfund Cleanup Program
      Fact Flash 5: Groundwater

    - copies for each student of the following maps from *Fact Flash 3: Flowing Railroad Hazardous Waste Site*
      Map 1, Flowing Railroad Site
      Map 2, Flowing Railroad Site Area
      Map 3, Diked Sludge Pond, Cross-Section

2. Read Fact Flashes 1, 2, 3 and 5 to prepare your lecture.

3. Distribute Fact Flashes 1 and 2 and assign students to read them as homework.

Procedure

Class #1

1. Review the main ideas from Fact Flashes 1 and 2.

2. Distribute Map 1, Flowing Railroad Site (from *Fact Flash 3: Flowing Railroad Hazardous Waste Site*). This is an overhead view of a fictional site showing where past industrial activities are thought to have taken place. Describe past site activities to the students, using the information in Fact Flash 3.

3. Distribute Map 2, Flowing Railroad Site Area (from Fact Flash 3). This is an overhead view of the towns, rivers, and some activities in the surrounding area. Describe the area to students using information from Fact Flash 3.

4. Ask students how they think contaminants might spread from the site. Possible answers include:

   - The wind can blow contaminant vapors.
   - The wind can blow small soil particles to which contaminants are attached.
   - Contaminants can be washed into the Flowing River by rainfall running off the site.
   - Liquid contaminants can flow down through the soil to the groundwater due to gravity.
   - Contaminants can be washed down through the soil to the groundwater by rainfall soaking into the soil.
   - Groundwater moving underground can spread contaminants in the aquifer.
   - Contaminated groundwater can move that uses the Flowing River.
   - Excavation or other activities that disturb the soil on the site can move contaminants.

5. Ask students how animals or plants may be exposed to contaminants from the site. Possible answers include:

   - The wind can blow contaminants to tree leaves, grasses, or crops.
   - Animals can eat contaminated plants.

- Fish and aquatic plants can be exposed to contaminants washed into the Flowing River.
- Farmland crops could be exposed to contaminants through the irrigation system that uses water from the Flowing River.

6. Ask students how people in Ruralville and Utopia may be exposed to contaminants from the site. Possible answers include:

   - Eating contaminated crops
   - Eating contaminated fish from the Flowing River
   - Utopia residents drinking contaminated water from their municipal wells
   - Ruralville residents drinking contaminated water from the Flowing River
   - Children playing on the site
   - Fishermen crossing the site to get to the Flowing River
   - Ruralville residents breathing air containing contaminated dust blown off the site
   - Ruralville and Utopia residents taking showers with contaminated water.

7. Ask students what factors would affect the amount of exposure from site contamination. Possible answers include:

   - Amount of contamination originally released at the site
   - Amount of dispersion of the contaminants
   - Amount of physical, chemical, and biological transformation of the contaminants into harmless compounds
   - Frequency of contact with contaminated water, soil, plants, and animals.

8. Explain to students that in a follow-up class, they will look more closely at how groundwater at the Flowing Railroad hazardous waste site may have been contaminated.

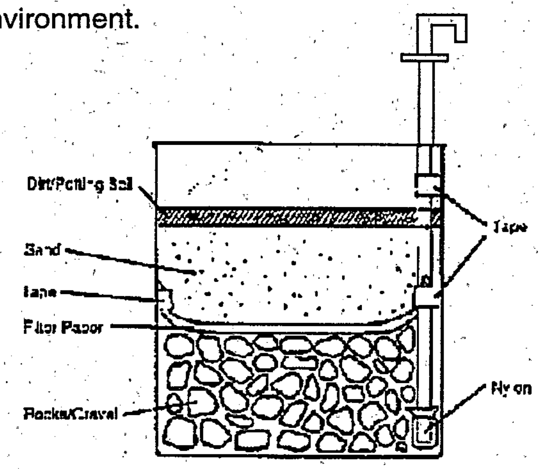
9. Distribute *Fact Flash 5: Groundwater* and assign students to read it prior to the next class.

Class #2

1. Distribute Map 3, Diked Sludge Pond, Cross-Section (from Fact Flash 3). Briefly review with students the main points in *Fact Flash 5: Groundwater,* assigned for reading after the first class.

2. Explain that groundwater contamination is a major concern in the Superfund Program, and it is difficult to visualize how contaminants move underground. Therefore, the class is going to construct a small groundwater model to explore how groundwater and contaminants move in an aquifer.

3. Construct a miniature model of a groundwater environment. Choose 2 or 3 students to build the groundwater model at the front of the class. (If you have enough supplies, divide the class into 4 groups and have each group construct its own model.) Use the illustration shown on the next page as a guide.



- Tape the pump mechanism, with the nylon fabric attached, to the inside of the container so that the nylon-covered end of the tube almost touches the bottom of the container.
- Fill the container about one-third full with the pebbles or gravel.
- Spread out the coffee filter and, if necessary, cut the paper to make a circle with a diameter larger than the diameter of the inside of the container. Place the filter paper on top of the pebbles and tape it to the sides of the container.
- Fill the rest of the container with sand. The filter paper will prevent the sand from falling down into the gravel and filling the spaces between gravel particles.

Your groundwater model is now ready for conducting experiments. Have students perform the following steps.

4. Spray water on the sand with the spray bottle, until the sand is saturated. The water will filter down through the sand and into the gravel. Keep spraying until the **water table** (the top of the portion of the ground that is completely saturated with water) is in the sand. Keep track of the amount of water that the container can hold at your selected water table level.

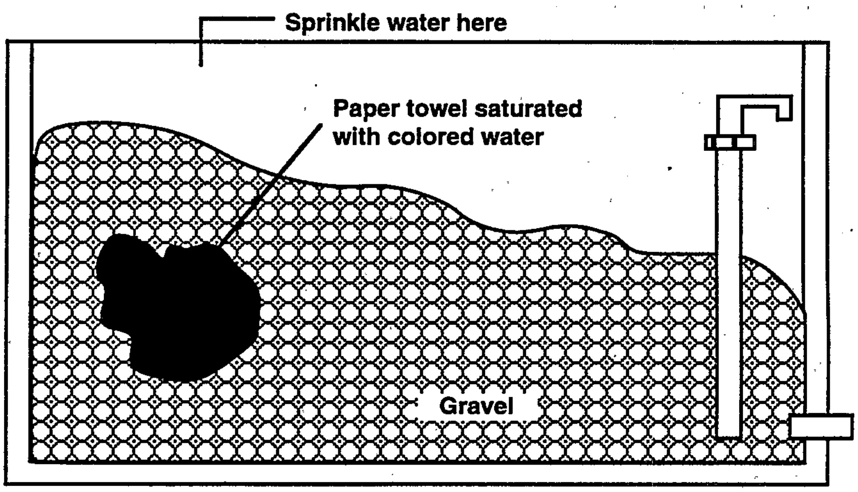
5. Push down on the pump mechanism and slowly draw a little water from the gravel through the tube and out of the pump. <u>Make sure the pump empties into the measuring cup.</u> Explain that the pump mechanism creates a vacuum to draw out the water. This is essentially the same method used to pump groundwater from **aquifers** (underground rock materials that are capable of storing and transmitting water in useful amounts).

6. Spray more water on the sand until you reach your original water level. Then add a few drops of red food coloring on top of the sand. Place one of the drops near the edge of the sand, near the wall of the container. Explain to the students that the food coloring represents a hazardous waste, such as gasoline, that dissolves in water.

7. Make it rain on your aquifer model by pumping the spray bottle 5 times.

8. Continue pumping water from the container into the measuring cup. The water in the cup will eventually have a reddish hue. Keep track of how much water you have to pump from your groundwater model. Discuss with the students how the pollutant at the surface level has contaminated the groundwater. This is similar to rainwater carrying contaminants underground and into an aquifer. Can the students make any observations about how the pollutant moves downward through the sand from the drop placed by the wall of the container?

9. Ask students to guess how much clean water will have to be sprayed onto the sand to remove all of the food coloring. Continue adding water to the sand and removing water with the pump until the students believe your groundwater has been cleaned up. How much water did it take to clean the aquifer? Was this close to what the students guessed?



NOTE: Another way to illustrate this is to build your model using only gravel. Attach the pump mechanism the same way as for the other model. Roll a paper towel into a ball and saturate it with red food coloring. Bury it beneath the surface (in the gravel). The buried paper towel represents an abandoned waste site. Add water until 1/4 of the pump is submerged. Then spray more water on the surface until 1/2 the pump is under water. Press the pump 20 to 30 times, catching the water in another container. Have students discuss what they observe.

10. To simulate the addition and removal of other types of contaminants, you can put other additives into the water. For example, use molasses or maple syrup to represent a **dense non-aqueous phase liquid (DNAPL)**—a substance that is heavier than water and will not mix with water. Contaminants like TCE and PCB are DNAPLs. Use vegetable oil to represent a **light non-aqueous phase liquid**

(LNAPL)—a substance that is lighter than water and will not mix with water. Jet fuel is an LNAPL. The amount of water that will have to be flushed through the groundwater; model should be significantly greater to remove these contaminants than what was needed to remove the red food coloring.

11. Ask students how your small groundwater model represents contamination at a Superfund site. Answers could include:

- Contaminants on the ground surface can be washed into groundwater by rainwater.
- Contaminants in groundwater can be removed by pumping out contaminated groundwater; however, the amount of water needed to clean contaminants from groundwater is far greater than the amount of contamination added.

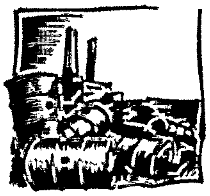
12. Ask students what is different between your experimental groundwater model and a real Superfund site. The following points could be made:

- A Superfund site can have thousands of gallons of contaminants in the groundwater as opposed to a few ounces.
- The subsurface at a Superfund site is far more complex than your groundwater model.
- The water in your model is contained, but at a real Superfund site it almost always is flowing slowly in one direction. Flowing groundwater at a Superfund site can carry contaminants miles from where the contaminants were spilled on the surface. This can make it very difficult to locate a contaminant source once contaminated groundwater is detected.

13. Ask students to consider the situation at the fictional Flowing Railroad site. Would the residents of Utopia be in greater danger from contaminated groundwater if the groundwater beneath the Flowing Railroad site was flowing north toward Utopia or south away from Utopia? *(The answer is that residents would be in greater danger if the groundwater was flowing away from Utopia. This may sound surprising, but the reason is that, if the groundwater is flowing away from Utopia, it is flowing towards their drinking water wells located 3 miles south of the Flowing Railroad site.)*

Extensions (Optional)

- Separate the class into 3 groups. Have each group make a different model: (1) use red food coloring to simulate a water-soluble contaminant; (2) use the buried paper towel described in the note and illustration on previous page; and (3) use maple syrup to simulate a DNAPL and/or vegetable oil to simulate an LNAPL. Have students observe a demonstration of each model and discuss the differences.



- Consider inviting an EPA or state Superfund employee involved in overseeing hazardous waste cleanup projects to discuss a real Superfund site in your state and what made it a Superfund site.

- As an extra credit project, advanced students could use a computer model to predict the movement of contaminants in groundwater under various conditions. Check your local telephone directory for the nearest EPA or United States Geological Survey (USGS) office and contact them about obtaining a copy of the groundwater models they use on a personal computer disk.

Activity 3

Companion to Superfund — the Resource Conservation and Recovery Act (RCRA) Program

Duration	2 1/4 class periods
Grade Level	9-12
Key Terms/ Concepts	Hazardous Waste Landfill Municipal solid wastes RCRA Underground storage tank
Suggested Subjects	Civics/Government Physical Science Social Studies

Purpose

This activity helps students understand our national program for properly disposing of the hazardous and nonhazardous wastes we generate. Students will learn about the Resource Conservation and Recovery Act (RCRA) and the regulations developed under the law that ensure that municipal and hazardous wastes are safely transported, treated, and disposed of. Students also will participate in a class activity to discover how their community handles the wastes they generate.

Background

Congress enacted the Resource Conservation and Recovery Act **(RCRA)** in 1976, to conserve energy and natural resources, reduce the amount of waste generated, and ensure that all wastes are managed in an environmentally sound manner. The U.S. Environmental Protection Agency (EPA) developed regulations to create the RCRA program. The program ensures the safe storage and disposal of wastes in three basic categories: (1) **municipal solid waste;** (2) **hazardous waste** and(3) **underground storage tanks** used for storing hazardous materials. Much of the program is operated by the states at the state level.

For more information on RCRA and hazardous and nonhazardous waste management, see the Suggested Reading list found at the end of the Haz-Ed materials. Other Haz-Ed materials that are related to this topic include *Fact Flash 7: Pollution Prevention* and *Activity 10: Pollution Prevention.*

Preparation

1. Gather the following materials:

   - Copies for each student of *Fact Flash 6: Resource Conservation and Recovery Act (RCRA)*

2. Read Fact Flash 6 to prepare for your lecture

3. Distribute Fact Flash 6 and have students read it for homework.

Procedure

Class #1

1. Discuss the RCRA program in class using the contents of Fact Flash 6, which students were assigned to read as homework.

2. Divide the class into teams and assign each team to gather facts on how your community addresses each of the waste disposal subjects listed below. *NOTE: You may need to call your local waste management agency prior to class to determine which of the subjects below are appropriate for your community.*

   <u>Municipal Solid Waste Landfill</u>: What does it do? Where is the **landfill** located? Who owns the landfill? Who operates the landfill? How much waste does it accept? What kind of waste does it accept? Where does the waste come from? What is the cost of disposal in the landfill? When was it built? When (in how many years) is the landfill expected to be full? What safeguards are in place to prevent contamination of the surrounding area?

   <u>Wastewater Treatment Plant</u>: What does it do? Where is it located? Who owns the treatment plant? Who operates the treatment plant? Where does the wastewater come from? How much water can be treated? What is the cost of water treatment? What kind of contaminants can be removed from water? What kind of contaminants cannot be removed? When was the treatment plant built? How many more years will it operate? What safeguards are in place to prevent overflows of contaminated water into the surrounding area?

   <u>Local Recycling Program</u>: Who runs the program? Where is the recycling center? Who pays for the program? How long has it been operating? What materials are collected? How are they collected? How much is collected per year? Does the

program pay for certain materials collected—for example, aluminum cans? What happens to the collected materials? Who buys the recycled materials from the program? How much money does the program get for the materials? What are the most difficult problems the program has to deal with to continue operating?

Local Composting Program: What is it? Who runs the program? Who pays for the program? How long has it been operating? What materials are collected for composting? How are they collected? How much is collected per month or per year? Where is the composting facility? Who gets to use the resulting compost? What are the most difficult problems the composting program has to overcome to continue operating?

Hazardous Waste Landfill: Where is it located? Who owns the landfill? Who operates the landfill? How much waste does it accept? What kind of waste does it accept? Where does the waste come from? What is the cost of disposal in the landfill? When was it built? When is the landfill expected to be full? Is hazardous waste treated before it is placed in the landfill? What safeguards are in place to prevent contamination of the surrounding area?

Underground Storage Tanks: How many underground storage tanks are there in the county or city? Where are most of them located? What kinds of materials are stored in the tanks? Who uses most of the underground storage tanks? Are the tanks old or new? What does it cost to buy and install an underground storage tank? Are any of the tanks leaking? Have any been replaced? What safeguards are in place to prevent the tanks from leaking?

Incinerator: What is it? Where is it located? Who owns the incinerator? Who operates the incinerator? How much waste can it burn? How much waste does it burn? What kind of waste does the incinerator facility accept? Where does the waste come from? How much does it cost to incinerate waste? When was the incinerator built? How many more years will it operate? What happens to the ash from the incinerator? What safeguards are in place to prevent contamination of the surrounding area?

3. Explain to the students that the purpose of this homework exercise is to identify what the community is doing now to handle waste generated in your area. Each team will gather information outside of class and prepare a report of their findings (2-3 pages).

4. Explain that each team is to make a short presentation on the results of their research during a follow-up class (specify the date). Allow each team to organize itself, assign specific tasks in order to complete the project, and select a spokesperson to make the team's presentation.

5. As a place for students to start gathering information, suggest that they call the RCRA/UST, Superfund, and EPCRA Hotline in Washington, D.C., which is open Monday through Friday, 9:00 a.m. - 6:00 p.m., Eastern Standard Time. The toll-free number is 800-424-9346; for the hearing impaired it is TDD 800-553-7672. The Hotline will be able to send publications and give students the names and phone numbers of EPA and state environmental department employees to call for more information on RCRA programs in your area. Other sources of information could include the local library and your county or local waste management agency, usually listed in a special section of your phonebook. Also, use the Contacts and Resources section at the end of the Haz-Ed materials.

Class #2

1. Have the spokesperson for each group present the group's findings from the research project to the class.
2. Encourage students to ask questions and discuss issues as they are raised.
3. After the presentations, encourage discussions that compare the facts presented. For example: Compare the amount of materials put in landfills with the amount of materials that are recycled or composted. Compare the actions taken at various facilities to prevent contamination of the environment. Discuss the cost of each type of waste management. Compare the types of wastes the various facilities accept and where these wastes come from.
4. Ask students to suggest how to improve the management of wastes generated by your community.

Extensions (Optional)

- A natural follow-up to these discussions is *Activity 10: Pollution Prevention.* It focuses specifically on what can be done to improve how waste is managed in your community.
- Consider inviting an EPA or a state employee involved in overseeing solid or hazardous waste programs to the class to describe the capacity available in your local landfill, how the location of the landfill was selected, what is being done to extend the life of the landfill, and any other relevant topics.

- Arrange a field trip to one of the types of facilities discussed in this activity. Many municipal landfills, incinerators, and so forth offer tours to the public.

- Have students use the newspaper or television news to track real waste disposal-related decisions made by your local government or industries. *Warm-Up 5: Hazardous Waste in the News* contains sample articles that you can distribute to the students to give them an idea of what to look for. You may want to use part of a bulletin board in your class to display newspaper articles relating to the subject. Set aside time periodically to discuss these actions and their potential impact on improving the local environment in the future.

- Consider showing a videotape describing waste management. Check with your school or local librarian and with local public television stations for educational videotapes describing municipal, household, or hazardous waste management. For example, the League of Women Voters of California's Education Fund produced two award-winning videotapes in 1990. *Cleaning Up Toxics at Home* and *Cleaning Up Toxics in Business* outline ways in which citizens and small businesses can significantly reduce pollution. Each tape is available for $29.95 ($49.95 for both) and may be ordered by calling The Video Project at 1-800-4-PLANET. Another video, called *The Rotten Truth*, was produced by the Children's Television Workshop for its *3-2-1 Contact* program. The video is available for $14.98, plus shipping and handling, by calling the distributor, Sony Wonder, at 1-800-327-3494.

Activity 4

Dealing with Chemical Emergencies

Duration	1 class period
Grade Level	7-12
Key Terms/ Concepts	Acute Chronic Emergency Exposure Hazardous material Release Residual Contamination Superfund
Suggested Subjects	Chemistry Physical Science

Purpose

This activity helps students understand how Federal, state, and local authorities respond to chemical emergencies. In a facilitated discussion, students identify activities that can result in spills and other emergency situations that may cause hazardous materials to be released. The difference between emergency situations and other times when hazardous substances may be released into the environment is explained. Students also discuss how Federal, state, and local authorities respond to spills and other releases of contaminants into the environment.

Background

The Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) directs the U.S. Environmental Protection Agency (EPA) and other Federal agencies to respond to **emergency** situations where **exposure** to **hazardous materials** poses an immediate risk of harm. Emergency situations covered by Superfund include chemical spills or fires. These situations require immediate action to reduce or remove toxic hazards and stabilize the contaminated area to prevent or minimize damage to people and the environment. Usually state and local authorities are the first at the scene of an emergency. After the immediate emergency has been addressed, the site is evaluated to determine whether additional work is necessary. If so, EPA, the state, or the responsible party will clean up the contamination.

For more information on emergency planning and response, see the Suggested Reading list found at the end of the Haz-Ed materials. Other Haz-Ed materials that are related to this topic include *Warm-Up 1: Defining Hazardous Waste* and *Warm-Up 2: EPA's Superfund Program—Overview.*

Preparation

1. Gather the following materials:

   - Copies for each student of:
     Fact Flash 1: Hazardous Substances and Hazardous Waste
     Fact Flash 2: The Superfund Cleanup Program

   - Copies for each student of the following Student Handout, *Hazardous Materials Emergencies.*

2. Read Fact Flashes 1 and 2 to prepare your lecture.

3. Distribute Fact Flashes 1 and 2 and assign students to read them for homework.

Procedure

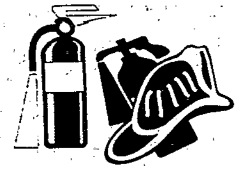
1. Review the characteristics of hazardous substances and the strategy for emergency responses under the Superfund Program, using the information in the Fact Flashes students read for homework. Point out that this discussion will focus on situations involving brief exposures to uncontrolled hazardous materials as happens in emergencies.

2. Ask students to recall any emergencies that have occured in their community or state involving chemical spills, explosions, fires, or other incidents involving a **release** of hazardous materials . Examples include a highway accident involving an overturned truck carrying hazardous materials, derailment of railroad tank cars carrying hazardous materials, an explosion at an industrial plant, or an evacuation of a neighborhood because of a hazardous materials spill or leak.

3. Have a student list the incidents mentioned on the chalkboard. Have students discuss the circumstances surrounding these events. What happened? What chemicals were released? Were the chemicals explosive, toxic, ignitable, or chemically reactive? How was the emergency resolved?

4. Distribute copies of the Student Handout, *Hazardous Materials Emergencies.* Give them 5 or 10 minutes to read it.

   Use the incidents in the Student Handout as a basis for discussion.



5. Ask students what activities and situations could result in accidents involving the acute release of hazardous materials. Make a list of these activities on the chalkboard, noting the names of any actual occurrences the class can name. Ask what these types of activities have in common, besides the handling of hazardous materials. *(This discussion should point out that many such incidents occur at industrial plants or when hazardous materials are transported and that many pose a threat to people in the vicinity.)*

6. Go back to the list of incidents on the chalkboard. Ask students to suggest what kinds of things would have to be done to respond effectively in each case. (For example, a chemical spill that contaminates drinking water could require an alternative supply of drinking water, or a chemical fire could require evacuating a neighborhood or a whole community.)

7. Ask students who they would expect to respond to these incidents. Would the response be handled locally or would it require outside help? Who would decide on the "action plan" for responding? How would they know what types of hazardous materials are involved? If you were responsible for making such decisions, what other sorts of information would you want?

8. Ask students what makes an emergency different from any other incident. Is it the materials involved, the threat posed to the general population, or something else? Does an emergency require some sort of sudden event (for example, an explosion, fire, train wreck)? What sort of "emergency" might not involve a sudden event (for example, a slow gasoline leak into a river)?

9. Explain to students that whether an incident is considered an emergency under the Federal Superfund Program depends on the type of threat posed. For example, explosions or fires in a chemical plant require an immediate response which, in turn, requires quick decisions and immediate action to reduce or eliminate hazards and stabilize the environment. Other threats, such as a gasoline leak, once under control, allow for a longer planning and decision making process related to the cleanup.

   NOTE: You may want to point out to students that the quick decisions needed to deal with an "emergency" can sometimes result in more long-term problems. For example, hundreds of miles of Germany's Rhine River were polluted following a chemical fire at Basel, Switzerland. Firefighters used water to extinguish the blaze. The runoff from the firefighting washed tons of chemicals into the river.

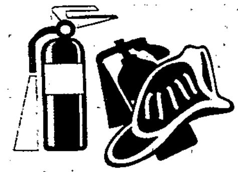
10. Ask students how they would decide that the "emergency" is over? What if there is leftover contamination? Who would they expect to deal with it?

Extensions (Optional)

- Invite local firefighters or emergency medical technicians to speak to the class on how their departments respond to chemical emergencies and how they interact with other authorities in these situations. Encourage the speakers to bring along any special equipment used in those situations.

- Ask for three volunteers. Assign one to visit the local police department, another the local fire department, and the third the local emergency medical service (EMS), which may be part of the fire department in some communities. Have the students interview officials about their chemical emergency preparedness. Have them explore how emergency calls are received and what plans are set into motion. What would happen locally in the event of a hazardous material emergency? What actual emergencies has the department handled? What is their interaction with state and Federal authorities in these situations? Have the students prepare and present the results of their interviews to the class.

- Invite an EPA or state On-Scene Coordinator (OSC) involved in overseeing hazardous waste cleanup projects to discuss a real emergency cleanup in your state or region. Use the Contacts and Resources listed at the end of the Haz-Ed materials.



Hazardous Materials Emergencies

Charlotte, New York, April 1995. A fire started at a tire dump in Charlotte, Chatauqua County, New York, about 40 miles southwest of Buffalo. The dump covers about 15 acres and holds from 2 to 3 million tires, which are stacked 12-30 feet deep throughout the dump. The cause of the fire was unknown. About 33 local fire companies responded and began efforts to isolate and control the fire, which engulfed 4 to 5 acres. Response personnel set up a containment area for runoff. EPA's On-Scene Coordinator responded to the scene to provide air monitoring and technical support to local response personnel.

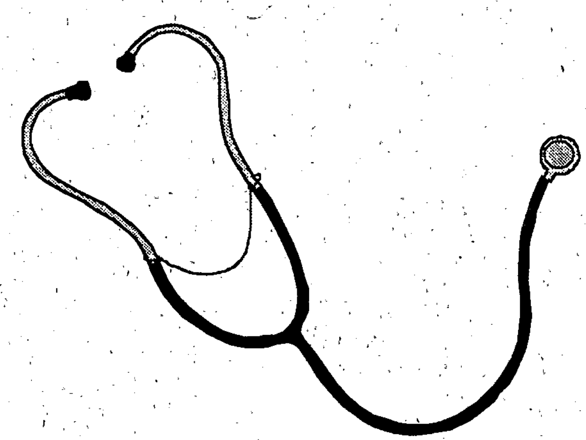
Lodi, New Jersey, April 1995. An explosion and fire at a plant that manufactures pharmaceutical chemicals killed at least 2 people, injured 12 others, and caused the evacuation of about 900 residents and schoolchildren in the area. EPA's On-Scene Coordinator and the Agency's Environmental Response Team responded to help local and state officials with air and water monitoring at the site. In addition, the U.S. Coast Guard sent a team to monitor the runoff of water used for firefighting into the Saddle River, where there were reports that fish had died.

Jackson, Mississippi, April 1995. More than 200 vials of the chemical phosgene and compounds used in tear gas were dug up during construction of a trench at the Mississippi State Fairgrounds. The vials reportedly came from World War I chemical warfare "test kits," buried in the 1930s in a pond that was later filled with dirt. EPA's On-Scene Coordinator provided on-site air monitoring and technical advice. U.S. Army teams inventoried the vials and packaged them for transfer to a military base for treatment and disposal.

Sargent Bluff, Iowa, December 1994. A rupture in a natural gas pipeline caused an explosion at a facility, about 15 miles south of Sioux City, Iowa, that manufactures urea and ammonium nitrate for fertilizer. The explosion reportedly killed 4 people and injured at least 30. The incident was initially reported by a nearby resident who said there was a strong ammonia smell in the area. Local firefighters and hazardous materials teams responded and evacuated the immediate area. Within an hour, the fire had been extinguished, but the release of contaminants into the air continued. EPA and state government officials were concerned about the additional release of materials, because the plant has large tanks of nitric acid, anhydrous ammonia, and ammonium nitrate that may have been impacted by the explosion. The facility is located along the banks of the Missouri River.

Activity 5

How Hazardous Substances Affect People



Duration	2 class periods
Grade Level	7-10
Key Terms/ Concepts	Adverse Health Effects Epidemiological Exposure Toxicology
Suggested Subjects	Biology Chemistry Life Science

Purpose

This activity helps students gain an appreciation for how scientists determine the human health effects of hazardous substances. Students also demonstrate how hazardous substances can affect the health of test animals.

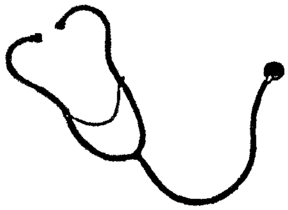
Note: This activity involves the exposure of worms to a hazardous substance. Some students may object to this on ethical or moral grounds.

Background

Toxicology is the study of the effects of poisons on living organisms. Scientists conduct a variety of studies to discover toxicological information about hazardous substances. Two of the most common types of studies are (1) **epidemiological** studies—matching disease and other **adverse health effects** in humans with possible causes—and (2) animal toxicological studies.

The Federal government's Superfund Program, administered by the U.S. Environmental Protection Agency (EPA), helps protect people and the environment by cleaning up hazardous waste sites. Well-designed, properly controlled epidemiological studies conducted at or near hazardous waste sites can provide information important in making cleanup decisions.

On their own, these studies are not always conclusive. This is primarily because it is difficult to determine the exact amount of the chemical or chemicals contaminating the site to which human populations have actually been exposed (had contact with). Many times health histories are incomplete, and potentially exposed populations are too small for statistical analyses. In addition, many uncontrolled variables—such as genetics, exercise, diet, or cigarette use—may complicate detecting the effects of the hazardous substances.



When epidemiological studies cannot be done, well-designed animal studies can provide a wealth of information. This information can be used to predict potential effects in humans over a range of **exposure** levels—from **acute,** a single exposure to a hazardous material for a brief length of time, to **chronic,** continuous or repeated exposure to a hazardous substance over a long period of time.

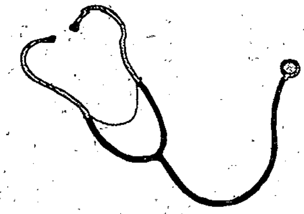
For more information on health effects caused by hazardous substances, see the Suggested Reading list found at the end of the Haz-Ed materials. Other Haz-Ed materials that are related to this topic include *Fact Flash 1: Hazardous Substances and Hazardous Waste; Fact Flash 9: Common Contaminants;* and *Activity 6: Examining the Effects of Pollution on Ecosystems.*

Preparation

1. Assemble the following materials:

    - Small plastic cups (5 per group)
    - Three empty one-liter plastic soft drink containers with caps
    - Refrigerated tap water
    - Automobile antifreeze (ethylene glycol)
    - Live, fresh-water black (hair) worms, sold as fish food in pet stores (50 or more worms per group)
    - 16-ounce measuring cup
    - 1-ounce measuring cup (used to measures doses of cough syrup)
    - plastic wrap
    - Tape and markers
    - Copies of the Student Handout, *Black (Hair) Worm Experiment* (1 per group)
    - Copies of the Student Worksheet, *Black (Hair) Worm Experiment* (5 per group)

    NOTE: Fresh-water hair worms are inexpensive, easy to see because of their dark color, and quite active. They survive best in a <u>*small amount*</u> *of refrigerated water (they die if submerged) and should be kept in the refrigerator until class time. If washed every day, they can live 1 to 2 weeks in the refrigerator. If worms are not available, you may substitute some other fresh water invertebrate, which can be obtained at tropical fish or pet stores. Brine shrimp, available at some pet stores, also may be substituted for fresh water invertebrates, but you will need to add table*



salt at a 5 percent solution in the water before adding the shrimp.

2. Fill each of the three 1-liter containers (they must be clean) with 16 ounces of water and clearly mark the 16-ounce level on the side. Pour out the water and shake the containers dry.

3. Label the containers either Low (6 percent), Medium (12 percent), or High (24 percent) ethylene glycol. For the low-dose solution pour 1 ounce of antifreeze in the container marked Low (6 percent) and fill up to the 16-ounce mark with water. For the medium-dose solution pour 2 ounces of antifreeze in the container marked Medium (12 percent) and fill up to the 16-ounce mark with water. For the high-dose solution pour 4 ounces of antifreeze in the container marked High (24 percent) and fill up to the 16-ounce mark with water. Shake or stir well. *(NOTE: Any substance can be toxic in a high enough concentration. Handle the antifreeze carefully.)*

4. Contact your local sanitation or health department to request information on the proper disposal methods for antifreeze in your community. Can it be poured down the drain? Is there a recycling center for this type of substance?

Procedure

1. Using the information in the Background section, discuss how scientists conduct studies to get information on toxic substances.

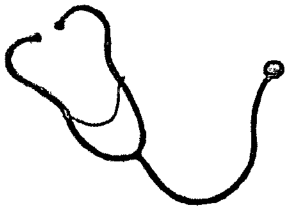
2. Divide the class into teams of two to four students each. **Caution students to handle the antifreeze carefully.**

3. Provide each team with five clean plastic cups, tape, marker, one copy of the Student Handout, and five copies of the Student Worksheet.

4. Have the students label the first container "low dose," the second "medium dose," and the third "high dose." Have them label the fourth container "control pre-test" and the fifth "control post-test."

5. Provide each team with some live worms. Have all groups pour just enough cold water into the "control pre-test" container to barely coat the bottom. Too much water will drown the worms.

6. Have the students place about 10 worms in the water and watch for any behavioral changes, recording the results at the end of 4 minutes on the Student Worksheet. Have them leave the worms in the container.



7. Have teams pour just enough water-antifreeze solution into each container to barely coat the bottom, using the solutions you prepared in advance. Have half of the teams start with the "low dose" container first and proceed in order to the "high dose." Have the other teams start with the "high dose" container first and proceed in order to the "low dose" container.

8. Have the students conduct each test one at a time, using different worms for each container (about 10 per container). Remind teams to record their observations for each test on the Student Worksheet.

9. Have all groups end the experiment by pouring just enough cold water to barely coat the bottom of the "control post-test" container. *(NOTE: Control observations at the beginning and end of the experiment are intended to help rule out effects not related to the antifreeze, such as water temperature.)*

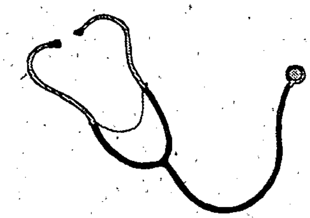
10. After the experiments, have each group describe the worm behavior they observed during each test and discuss the answers to the questions on the Student Worksheet.

11. Have students dispose of the antifreeze solutions properly, according to the information you received from your local sanitation or health department.

Extensions (Optional)

- Have the students plan and conduct an experiment to determine if there is a concentration of antifreeze and water that does not appear to change the behavior of the worms over a 24- or 48-hour period. The purpose is to determine if there is a threshold for an acute (rapid) effect; in other words, a level of exposure below which there is not likely to be an adverse health effect in the short-term. The students' experimental plan should at the very least include an appropriate control group, a sufficient number of worms, observation procedures, and an explanation of the experimental conditions, including procedures for rinsing the worms once a day, cleanliness, covering containers to prevent evaporation, and refrigerator temperatures.

- Have the students search the library for information on worm biology. Focus their attention on worm anatomy and physiology, function in ecosystems, and whether the adverse effects of antifreeze on worms might be compared to the potential effects of antifreeze on human health or ecosystem health.



Teacher's Answer Key — Black (Hair) Worm Experiment

(1) **Were there obvious behavioral differences between the control groups and the antifreeze-exposed groups? If yes, describe.**

There should be differences in mobility even with only 10 animals per group. After about 10 minutes nearly all worms exposed to the antifreeze solutions probably will be dead. The higher the concentration of antifreeze the faster they die. Also, the smaller the worms (young worms) the faster they die. In the unlikely event there are no differences between treated and control groups, perhaps more worms per group are needed, or the antifreeze concentration is too low to cause an observable effect, or the worms are not susceptible to the adverse effects of antifreeze. All of these possibilities could be tested in another experiment if materials allow.

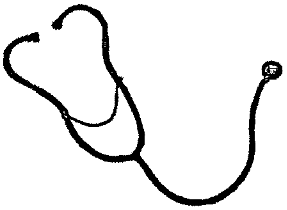
(2) **Did the concentration of antifreeze in the water influence the degree of behavioral change? If yes, describe.**

After an initial increase in activity, you should find that the higher the dose, the more quickly the worms' mobility decrease. The degree and severity of toxic effects are primarily a function of dose (the amount of contact or exposure to the chemical). However, many other factors including differences in susceptibility among individuals within a species also influence the outcome. Because humans manifest an unusual degree of individual variability, large numbers of people must be similarly exposed to clearly demonstrate that a chemical causes a specific toxic effect. Using animal toxicity studies to determine the potential adverse effects of specific substances has many advantages. Genetically similar individual animals can be used in relatively large numbers and exposures can be controlled over a range of dose levels. The results of animal toxicological studies are used to predict potential effects in humans at dose levels relevant to possible human exposures.

(3) **Was there a safe level of exposure? In other words, was there an antifreeze solution that did not appear to cause an effect over the 4-minute observation period? How could you tell?**

Ideally, at least one dose level in an experiment should have an observable effect different from the others during the observation period. That is, if all the doses cause the same reaction, you have only learned that antifreeze has an effect at a concentration equal to or greater than the lowest dose used. You have not determined the minimum concentration that will cause an effect, or the maximum concentration that has no effect.

If all three doses in your experiment caused the same reaction during the 4-minute observation period, you may want to repeat the experiment using a lower concentration. For example, you could prepare a 3 percent solution by pouring 1/2 oz. of antifreeze into one of the liter containers you used earlier, and filling it up to the 16 oz. mark with water. Then repeat the experiment using this solution and observe the reaction. Are the results different after 4 minutes? How about after the total time that elapsed during the other experiment?



(4) Does the acute (rapid, short-term) effect of antifreeze on the worms indicate anything about what the long-term or chronic (lifetime) effects might be?

No. Long-term or chronic exposures to hazardous substances frequently result in different effects from those observed after only a brief exposure. This makes the effects of long-term exposure more difficult to link to a specific cause. Reproductive organs may be affected; mutations in cell structure, liver damage, and so forth may not show up until the next generation.

(5) Is behavior the only possible measure of effect? Why or why not?

Although behavior is an inexpensive indicator of a potentially fatal adverse effect, it is not the only measure of effect. It is used in this experiment because it does not require sophisticated equipment to study.

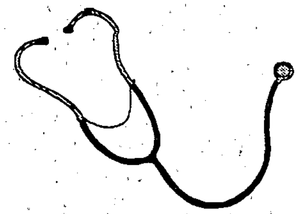
(6) Can you determine from this experiment the cause of death of the worms?

No. Damage could have been done to vital organs such as the liver and kidney, which would subsequently make the worms too sick to move, or the antifreeze could have directly affected their neuromuscular system, brain, sensory systems, and other organs, thereby slowing their mobility.

Hazardous substances adversely affect living organisms through a variety of mechanisms, many of which are not yet known. Some chemicals alter DNA, damage DNA repair mechanisms, or destroy cells by damaging their membranes, interacting with cell receptors, depleting substances essential to cell survival, or inhibiting production of vital enzymes. Some potentially hazardous substances are not hazardous until the body breaks them down (or metabolizes them) into substances that are toxic. For example, carbon tetrachloride is broken down in the liver to a highly reactive chemical that initiates a chain reaction which destroys a crucial liver cell enzyme system (cytochrome P-450).

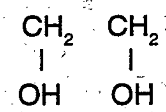
(7) Is it possible that while antifreeze affects the health of worms, it has no effect on humans? Is it also possible that antifreeze has no effect on worms but adversely affects human health? If yes, describe.

The answer to both is yes. However, epidemiological studies and accidental poisonings verify that antifreeze causes serious and often fatal effects when ingested by humans. The liver breaks down ethylene glycol into aldehydes, glycolate, oxalate, and lactate that may initially cause nausea, seizures, respiratory failure, coma, and cardiovascular collapse. Survivors of the acute phase ultimately exhibit kidney failure, severe acidosis (lowered blood pH), and low blood calcium levels. The fatal kidney damage results mainly from the formation of oxalate-calcium crystals that precipitate in the kidney tubules. These changes may also occur in the liver, heart, blood vessels, and brain. In addition, the aldehydes, glycolate, and lactate acidify the blood to dangerous levels.



Black (Hair) Worm Experiment

The purpose of this experiment is to determine the potential effect of three concentrations of antifreeze (ethylene glycol) on fresh-water worms. There are five steps.



ethylene glycol

Your teacher will provide you with:

- Five small, clean plastic cups
- Live, fresh-water black worms (hair worms)
- Tape and markers
- Five copies of a Student Worksheet for recording your observations
- Antifreeze (ethylene glycol) solutions of 6 percent, 12 percent, 24 percent
- Refrigerated tap water.

Step 1 Label one cup "low dose," the second cup "medium dose," the third cup "high dose." Label the fourth cup "control pre-test" and the fifth cup "control post-test."

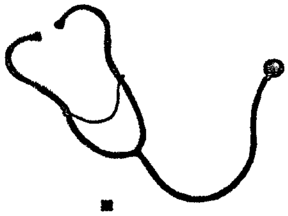
Step 2 Add just enough cold tap water to barely cover the bottom of the container marked "control pre-test," and place about 10 worms in the water. ***(DO NOT SUBMERGE THE WORMS: THEY WILL DIE.)*** Observe the worms for 4 minutes and watch for any changes in their behavior. Record the results on the appropriate line of the Worksheet. Set the "control pre-test" cup aside, but do not throw it away.

Step 3 After recording the behavior of the "control pre-test" group, conduct similar observations of different worms (about 10 per cup) in order from "low dose" to "high dose" or from "high dose" to "low dose" depending on your instructor's directions. Use the appropriate antifreeze mixture prepared by your instructor for each dose level. Use the Worksheet to record the behavior of each group of worms at the end of 4 minutes.

Step 4 After you have observed the results from all 3 solutions, repeat the control test by again adding barely enough cold water to cover the bottom of the cup labeled "control post-test," and place about 10 worms in the water. Observe for 4 minutes for any behavioral changes. Record the results on the Worksheet.

Step 5 At the end of the experiment observe the total time and take one last look at the worm behavior in all of the cups.

Step 6 Answer the questions on the Worksheet.



Black (Hair) Worm Experiment

Test	Behavior after 4 minutes	Behavior at end of experiment	Total time from start of experiment
control pre-test low dose medium dose high dose control post-test			

Answer the following questions

(1) Were there obvious behavioral differences between the control groups and the antifreeze-exposed groups? If yes, describe.

(2) Did the concentration of antifreeze in the water influence the degree of behavioral change? If yes, describe.

(3) Was there a safe level of exposure. In other words, was there an antifreeze concentration that did not appear to cause an effect over the 4-minute observation period? How could you tell?

(4) Does the acute (rapid, short-term) effect of antifreeze on the worms indicate anything about what the long-term or chronic (lifetime) effects might be?

(5) Is behavior the only possible measure of effect? Why or why not?

(6) Can you determine from this experiment the cause of death of the worms?

(7) Is it possible that while antifreeze affects the health of worms, it has no effect on humans? (Is it also possible that antifreeze has no effect on worms but adversely affects human health?) If yes, describe.

Activity 6

Examining the Effects of Pollution on Ecosystems

Duration	2 to 3 class periods
Grade Level	10-12
Key Terms/ Concepts	Acute Bioaccumulation Biomass Community Ecosystem Environment Population Relative abundances Species abundances
Suggested Subjects	Biology Chemistry Life Science Physical Sience

Purpose

This activity helps students recognize that hazardous waste may have far-reaching impacts on ecosystems and these impacts are not always easy to identify. Students become familiar with several types of tests used to measure the environmental effects of hazardous waste pollution. In the process, they learn that no single assessment procedure is applicable to all ecosystems and no single test is adequate to assess pollution impacts on an entire ecosystem. They examine a case study and discuss the limitations of current ecosystem assessment methods for establishing cause-and-effect relationships, especially for mixtures of chemicals in the environment.

Background

The impact of hazardous waste on the environment is thought to be widespread and in some areas severe. Establishing cause-and-effect relationships between exposure and ecosystem damage is a major challenge. An **ecosystem**—such as a marsh—is a highly complex structure, consisting of all living organisms in a given area and their interactions not only among themselves but also with the **environment**. Even a mature ecosystem—one that has achieved stability over time—is constantly adapting to changes. Some of these changes are due to natural influences such as animal migration patterns, weather, erosion, and sedimentation. Other changes, however, are the result of habitat encroachment and human pollution. This pollution is often in the form of complex mixtures of chemicals in widely varying concentrations.

Ecosystems are complex and dynamic (ever changing). This makes linking any one effect to a specific cause very difficult. Conditions cannot be controlled sufficiently to allow the effects of individual pollutants to be observed. Only recently have scientists begun to focus attention on finding ways to determine the major effects of hazardous waste on ecosystems.

Researchers have built laboratory models of ecosystems to study environmental pollution in controlled settings. But models can provide only simple representations of real ecosystems that contain thousands of living species. They cannot provide adequate measures of the diversity of species and the complexity of the relationships among all the living organisms that make ecosystems unique.

There is no single best strategy or design for assessing environmental pollution that is appropriate for every situation. The characteristics of the area and the specific objectives and issues of concern must be considered in determining how to proceed. Nevertheless, scientists generally use four major categories of tests to assess the impact of hazardous waste on ecosystems:

- **Chemical and physical tests** to measure contaminant levels, pH, oxygen levels, and other environmental conditions
- **Toxicity tests** to determine if the pollution can or is causing adverse biological effects in ecosystem species
- **Biomarkers** to indicate actual exposure
- **Field surveys.**

These ecological assessments are important tools in Federal and state government efforts to clean up hazardous waste contamination under the Superfund Program.

For additonal information on ecosystems and pollution, see the Suggested Reading list found at the end of the Haz-Ed materials. Other Haz-Ed materials related to this topic include *Fact Flash 2: The Superfund Cleanup Program.*

Preparation

1. Assemble the following materials:
   - Copies for each student of Student Handout 1, *Major Categories of Tests for Ecological Assessment,* found at the end of this activity
   - Copies for each student of Student Handout 2, *Case Study: Tidal Bay Ecological Assessment.*

2. Read the student handouts to prepare your lecture.

3. Distribute copies of Student Handout 2 and assign students to read the case study for homework.

NOTE: In this lesson, students will encounter a large number of scientific terms and phrases. Depending on the grade level in which you use the lesson and the skill level of your students, you may need to spend extra time introducing unfamiliar vocabulary and preparing your students for this lesson. Many terms are defined in the Glossary found at the end of the Haz-Ed materials, but a textbook may be helpful.

Procedure

Class #1

1. Ask the class to define an **ecosystem**. Then ask the class to distinguish between an ecosystem and the environment. (An ecosystem is a specialized community, including all the component organisms, that forms an interacting system, for example, a marsh. An environment is the totality of conditions surrounding an organism.)

2. Organize the students in groups of 3 or 4 students each, and ask each group to write down how hazardous waste released into the environment can affect plants (flora) or animals (fauna) in an ecosystem. Ask them to list as many possibilities as they can think of in 10 minutes.

3. Ask each group how many ideas they wrote down.

4. Ask the group with the fewest ideas to lead off by naming one effect of pollution. Ask the rest of the class if they agree that the named effect can result from pollution. Ask those who agree to explain why they agree. Ask those who do not agree to explain their reasons.

   Continue the discussion by asking each group in turn to add to the list. Have a student write the ideas on the chalkboard as they are mentioned. Some possible effects that could be listed include:

   - Gaps in vital food chains or nutrient cycles
   - Reproductive problems (such as eggshell thinning or loss of nesting materials)
   - Developmental effects (such as malformed chick beaks)
   - Tumors (such as fish tumors)
   - Critical organ damage (such as liver, kidney, or skin lesions)
   - Immune system dysfunction (leading to, for example, viral infections in dolphins)
   - Altered individual or population growth rates
   - Changes in population and community organization
   - Loss of total **biomass** (flora and fauna)

- Relative loss of **taxa** or **species abundance** in defined areas (such as fish kills, amphibian mortality, **macroinvertebrate** depletion)
- Loss of species diversity.

Some of the students' ideas may overlap because one adverse ecosystem effect can impact another since life in ecosystems is interdependent. For example, reproductive and developmental problems in birds may ultimately cause a decrease in species abundance and diversity, which in turn may alter community organization.

Students may not come up with many ideas. In a way this reflects the current state-of-the-science in ecological assessment. It can be difficult to determine what is occurring or could occur in an ecosystem as a result of pollution; effects are often very subtle unlike those of habitat loss, which usually tend to be very obvious.

Leave the list on the chalkboard.

5. Distribute the Student Handout, *Major Categories of Tests for Ecological Assessment*. You may wish to have students discuss the various types of tests in more depth before proceeding.

6. Ask the students which category or categories of tests could be used to study each of the adverse effects listed on the chalkboard. Have students explain the choices they make. Encourage the rest of the class to comment on various answers.

Class #2

1. Give each student a copy of the Student Handout, *Case Study: Tidal Bay Ecological Assessment*. Give them about 30 minutes to read it in class or as homework. Questions and guidelines are in the text to assist them in their review. Ask them to answer as many of the questions as possible.

2. For the remainder of the class period, discuss the case study and the students' answers to the questions. An *Instructor's Answer Key* is included at the end of this lesson for your use.

Extensions (Optional)

- After allowing each group to add to the list of ideas about how hazardous waste can adversely effect ecosystems, ask students to rank the items according to their importance. Have them discuss their choices.

- Point out during the discussion that sometimes investigators limit ecological components of concern to commercially important species (e.g., blue crabs in the Chesapeake Bay). Have students discuss how this might influence public attitudes with respect to proposed environmental regulations or legislation.

Instructor's Answer Key – Handout 1

Case Study: Tidal Bay Ecological Assessment

1. *What are the benefits of comparing contaminant concentrations and biological impacts in Tidal Bay sediments with those of a reference area?*

   By expressing all chemical and biological measures as changes (increases or decreases) relative to a "normal" ecosystem (Shipshape), comparisons can be made that provide a sound basis for identifying and quantifying effects. Comparing results with a reference area allows investigators to determine not only what is not "normal" in the study area, but also how much weight to place on the changes.

2. *What are some of the limitations (problems) associated with the use of a reference area and with the choice of Shipshape Inlet as this area?*

   Shipshape Inlet differs in sediment type from Tidal Bay, and although it may be the least polluted area of those studied in the basin, it is hardly a pristine environment unaltered by urbanization and industrialization. Furthermore, comparing a complex biological response such as benthic macroinvertebrate community change with a reference site requires reducing the data to a single value(s), which results in a substantial loss of data.

3. *Can you think of another approach that would work?*

   If Tidal Bay contained only one or possibly two specific wastes, the contaminant concentrations and biological measures of their impact on the ecosystem could be compared with toxicity and risk levels published in the literature or in government databases. It is not known, however, how complex chemical mixtures interact to possibly increase or decrease the effects of individual chemicals. Further, the exact combination of chemicals in Tidal Bay may be unique. So, under these circumstances, the use of a reference area is probably the best choice.

4. *What impact do you think the presence of multiple types of hazardous waste will have on the ability of investigators to establish a cause-and-effect relationship between specific chemicals and adverse biological changes in Tidal Bay?*

   Ideally, characterization of ecological impacts from hazardous waste is supported by definitive cause-and-effect relationships between specific chemicals and biological endpoints. Almost no information is available for establishing cause and effect for chemical mixtures, however, so they will not be able to determine specific cause and effect relationships. In lieu of a standardized approach for assessing ecological impacts of complex chemical mixtures, the Tidal Bay investigators developed relative measures of effect based on the reference area.

5. *Do you feel these measurements are relevant to this aquatic ecosystem?*

A number of biological measures are used to quantify the pollution impact on Tidal Bay. These include several toxicity tests, benthic community composition, and fish histopathology. All of these measures can be justified on ecological grounds. For example, amphipods are crustaceans that reside in Tidal Bay and are important prey for higher trophic-level species like fish. Also, they are relatively sensitive to toxic chemicals and are highly likely to be exposed to contaminants because they burrow in and feed on sediment material.

Oysters also are considered useful indicators of ecological effects because they are very sensitive to toxic chemicals. The oyster test is a standardized test of developmental effects, which provides a broader view of adverse effects than lethality tests alone.

Benthic macroinvertebrate species also are valuable indicators of toxicity because they live in direct contact with sediments, are relatively stationary, and are important components of aquatic food chains. Many fish and crab that live near the sediment feed on benthic organisms and are exposed to contaminants through the food chain.

Note: Although the investigators avoided limiting ecological components of concern to commercially important species or to those selected for the sake of political expediency, the ecological significance of the effects observed in the bioassay tests is not explained in terms of the entire ecosystem of Tidal Bay.

6. *Are these measurements likely to furnish the kind of data required to fulfill the purpose of the assessment? If not, how would you change the approach?*

The use of multiple chemical and biological tests (such as sediment chemistry, sediment toxicity, benthic macroinvertebrate assemblages, tissue residues resulting from bioaccumulation, and fish liver histopathology) provides a powerful weight-of-evidence approach to identify pollution problems in an ecosystem. They also provide the kind of data needed to define the extent of hazardous waste contamination in estuarine sediments and the magnitude of damage to benthic organisms and fish.

7. *Investigators characterized degradation of benthic macroinvertebrate communities in terms of a decrease in the abundance of total amphipods, molluscs, polychaetes, or total macrofauna. Many conditions can influence the overall abundance of benthic macroinvertebrates, including an algae bloom that depletes oxygen in the water. Did the investigators' report consider all factors that could have altered macroinvertebrate numbers?*

   While some species may decrease in abundance due to chemical pollutants, other, more pollution-tolerant species are likely to increase. This makes changes in abundance at a major taxon level or at the total macrofauna level an unreliable indicator of ecosystem health. Generally speaking, a chemical pollution problem is the only condition that will render a waterway totally devoid of macroinvertebrates. However, the investigators did not study the levels of macroinvertebrate species in detail, possibly because of the extra costs involved. Precise and careful analyses of macroinvertebrate samples is time consuming and expensive. Also, they did not report looking at other possible causes for macroinvertebrate depletion.

8. *Could apparent effects thresholds be determined for bioaccumulation and histopathology in fish? Why do you suppose investigators did not do this?*

   Apparent effects thresholds could have been established for bioaccumulation and histopathology in fish, but the purpose of the apparent effects thresholds was to rank specific problem areas within the bay. The fish indicators reflect a wide area of conditions. Also, there is a lot of uncertainty associated with how much hazardous waste the fish have been exposed to in the water and food chain and for how long. Thus, it is difficult to link the bioaccumulation and histopathology data directly to chemical concentrations in specific sediment samples.

9. *What are some major strengths of the apparent effects thresholds and what are some limitations?*

   The apparent effects thresholds method is a plausible approach for dealing with problems created by contamination and uncertain cause-and-effect relationships. It uses empirical relationships to get around difficulties like bioavailability and synergistic and antagonistic relationships among chemical mixtures. The approach is limited for several reasons: it does not describe cause-and-effect relationships, it is site-specific (specific to certain areas), does not take into account data on bioavailability of chemicals in organ tissues, and lacks independent validation.

Major Categories of Tests for Ecological Assessment

There are 4 major categories of tests scientists use to study the effects of pollution on ecosystems:

1. **Chemical and Physical Tests** provide information on the total concentration of specific chemical compounds in the ecosystem and information on pH, temperature, moisture, and other measures. Samples of soil, sediment, or water are collected and usually taken to a laboratory for testing using several standard laboratory methods.

2. **Toxicity Tests** measure the number and severity of biological effects of contamination on the survival, growth, and reproduction of plants and animals. Most toxicity tests are conducted in the laboratory using laboratory-raised species or organisms collected in the field (from the ecosystem). Examples include:

   - **Acute** test (number of animal deaths) using field-collected specimens or test species such as earthworms or fathead minnows
   - Chronic growth, tumor, and functional tests of selected species (usually the most sensitive species)
   - Multigenerational reproduction and developmental tests of specific species
   - Gene and chromosome tests
   - Plant mutation tests such as stamen hair
   - Photosynthesis rates (usually tested in field)
   - Seed germination
   - Root elongation

3. **Biomarkers of Exposure** are sensitive indicators of a physiological, anatomical, or biochemical response to pollution exposure such as abnormal blood changes. They can be used as sensitive monitoring tools for detecting exposure. Individual organisms usually are obtained from the ecosystem and their blood and body tissues are examined. (Biomarkers are not considered adequate measures of biological effects at the population, community, and total ecosystem levels of organization.) Examples include:

   - **Bioaccumulation** tests indicate the level of chemical pollution that has gathered in an individual animal or plant and the availability of those pollutants to vulnerable tissues inside the body.

   - Blood enzyme levels are used to assess exposure to certain pesticides.

   - Histopathologic tests using light microscopy, electron microscopy, and chemistry involve examinations of specific tissues and organs like the liver and kidney to detect chemical damage. *(Histologic exams often are used in long-term and chronic toxicity tests to confirm findings.)*

4. **Field Surveys** involve observations in the ecosystem and tests on field-collected samples. Field surveys require many sampling excursions to avoid over- or underestimating. Examples include:

   - Abundances of native species and numbers of individuals within those species

   - **Relative abundances** of major taxa to determine community-level effects

   - Number of individuals with offspring

   - Estimates of total biomass (mass of tissue present in an individual, population, or community at a given time) or biomass of certain communities such as phytoplankton

   - Guild structure (functional feeding groups such as collector-gatherers or predators based on how organisms obtain their food) may change as a result of exposure to contamination. This can alter levels of competition for common resources.

Case Study: Tidal Bay Ecological Assessment

This case study is an example of how one scientific group attempted to document the impact of a mixture of organic compounds and metals on an estuary, fictitiously named Tidal Bay. Although there is no single best strategy or design for ecological assessments that is appropriate for every ecosystem, the assessment techniques and lessons learned in this case study have implications for measuring the impact of pollutants in other ecosystems where water—fresh, tidal, or marine—is contaminated or threatened.

Directions:

1. *Critique this case study using the questions provided. <u>You may not understand all of the detail provided; for example, you probably will not be familiar with all the animal species and chemicals</u>. This should not limit your ability to see the logic underlying the investigation and the strengths and weaknesses of the approach. In the process, you will discover a lot about environmental science.*

2. *Read through the entire case study first, and then in a sentence or two answer each question.*

Approach

Purpose

This ecological assessment was conducted for the purpose of defining the extent of hazardous waste contamination in the tidal sediments (soil, stones, or other materials deposited by tidal waters) of Tidal Bay and to measure the magnitude of existing biological damage to **benthic** (bottom-dwelling) organisms and fish. It was not intended to be a risk assessment since it did not investigate the future of the ecosystem.

Concept

Concerns about the potential ecological and human health effects of hazardous waste in Tidal Bay focus on exposure of aquatic organisms to contaminated marine sediments. The sediments support a variety of benthic organisms that can be directly influenced by sediment contamination. Benthic macroinvertebrate species, such as shrimp, are valuable indicators of toxicity because they live in direct contact with sediments, stay close to their homes, and are important parts of aquatic food chains. Many fish and crabs that live in or near the sediment feed on benthic organisms and are exposed to contaminants through the food chain. Therefore, if tests on these benthic macroinvertebrates do not reveal negative effects caused by polluted tidal; sediments, it is unlikely that other biological groups, such as fish or plankton, are affected by these pollutants. For example, if the shrimp that live in the sediment are tested and have nothing wrong with them, the crabs and fish will probably be fine too, since they eat the shrimp.

Description of Area

The study area is a bay formed by a river delta made up of seven minor waterways, associated shorelines, and water at depths less than 60 feet below low tide. Tidal Bay is in a heavily industrialized area at the south end of a large basin. Industrial and municipal sources, such as a pulp mill, petroleum refineries, chemical manufacturers, aluminum processors, and a shipbuilding and repair yard are located on filled-in tideflats. A municipal sewage treatment plant discharges into the river upstream of the bay.

Selection of Reference Area

A reference area, Shipshape Inlet, was selected to compare against the contaminated sites in Tidal Bay. Chemical and biological measures taken in Tidal Bay are compared to this reference site. Shipshape Inlet was chosen because it is associated with the same large basin that includes Tidal Bay and has some of the lowest levels of the contaminants of concern in the basin. Also, an extensive amount of chemical and biological data are already available on Shipshape Inlet. The range of sediment types in Shipshape Inlet, however, does not include the fine-grained sediments characteristic of the Tidal Bay waterways.

Chemical Pollutants

Routine chemical tests for about 150 chemicals were completed on over 190 samples of surface and subsurface sediments collected from areas of the bay. Chemicals detected in more than two-thirds of the surface sediments include phenol, 4-methylphenol, polycyclic aromatic hydrocarbons (PAHs), 1,4-dichlorobenzene, polychlorinated biphenyls (PCBs), dibenzofuran, and metals.

The chemicals present in Tidal Bay at higher concentrations than those in Shipshape Inlet are causing the greatest concern. Twelve chemicals or chemical groups were at concentrations greater than 100 times and less than 1,000 times those in Shipshape Inlet. Nine chemicals or chemical groups were at concentrations greater than 1,000 times those in Shipshape Inlet.

1. *What are the benefits of comparing contaminant concentrations and biological impacts in Tidal Bay sediments with those of a reference area?*
2. *What are some of the limitations (problems) associated with the use of a reference area and with the choice of Shipshape Inlet as this area?*
3. *Can you think of another approach that would work?*
4. *What impact do you think the presence of multiple types of hazardous waste will have on the ability of investigators to establish a cause-and-effect relationship between specific chemicals and adverse (negative) biological changes in Tidal Bay?*

Measurement

To assess the health and condition of the selected animals (benthic macroinvertebrates and fish), several measurement endpoints were evaluated. These included:

1) toxicity tests using sediment species, population abundances, and community indicators (species richness and community similarity)
2) biomarkers for tissue residues of contaminants and fish histopathology (microscopic examinations of specific tissues and organs to detect chemical injury)
3) chemical tests of contaminants in the sediments.

The sediment toxicity tests were conducted in the laboratory using amphipods, oysters, or bacteria, and field-collected sediment samples with known chemical concentrations. Bioassays were repeated using the same sediment samples that were diluted to lesser contaminant levels.

The amphipod toxicity test measures death rates in a crustacean that resides in Tidal Bay and is an important prey for higher species like fish. Amphipods are relatively sensitive to toxic chemicals and are likely to be exposed to contaminants because they burrow in and feed on sediment material.

Although oysters do not live in Tidal Bay, they reside in other areas of the basin, and oyster embryos and larvae are very sensitive to toxic chemicals. The oyster toxicity test measures the occurrence of developmental abnormalities in larvae (and embryos) exposed to Tidal Bay sediments for 48 hours.

Abundances of benthic macroinvertebrates were determined from field-collected samples. Community indicators involved counting species richness and the amount of major taxa such as crustaceans and molluscs. Only decreases in abundances of major taxa in Shipshape Inlet were used to identify and rank problem areas in the bay. Bioaccumulation (contaminant concentrations in muscle tissue) of English sole (fish) and Dungeness crab were measured as biomarkers of exposure. Because contaminants were detected infrequently in the crab muscle tissue, only the English sole data were used to identify and rank exposure levels. Histopathological tests were conducted on the livers of English sole.

The magnitude of exposure was determined by the chemical concentrations of contaminants in sediments. Because sediments represent a sink for pollution (that is, pollutants tend to accumulate in sediments), organisms that live in it or on it are continuously exposed.

A number of measurements were used to quantify contaminant impact on the ecosystem. These include several bioassay species, benthic community composition, bioaccumulation, and fish histopathology.

5. *Do you feel these measurements are relevant to this aquatic ecosystem?*

6. *Are these measurements likely to give the kind of data required to fulfill the purpose of the assessment? If not, how would you change the approach?*

7. *Investigators characterized degradation of benthic macroinvertebrate communities in terms of a decrease in the abundance of total amphipods, molluscs, polychaetes, or total macrofauna. However, many conditions can influence the overall abundance of benthic macroinvertebrates including an algae bloom that depletes oxygen in the water. Did the investigators consider all factors that could have altered macroinvertebrate numbers?*

Analysis

The analysis of the ecological effects and exposure data involved mainly statistical comparisons of test results from Tidal Bay and the reference area. For example, Tidal Bay sediments from 18 of 52 tested areas induced significant, acute lethality in amphipods as compared with the reference area sediments. Significant elevations in oyster larvae abnormalities occurred in sediments from 15 of 52 areas tested compared with sediments from the reference area. Significant decreases in the abundance of total taxa and the abundance of polychaetes, molluscs, and crustaceans occurred in 18 of 50 areas tested in Tidal Bay compared to the reference area.

Concentrations of most metals in the muscle tissue of English sole were less than 2 times the average reference concentrations, but concentrations of copper in the Tidal Bay fish tissue were 3 to 9 times higher than average reference concentrations. Polychlorinated biphenyls (PCBs) were detected in all fish and crab sampled. Lead and mercury were elevated in Dungeness crab with maximum concentrations about 5 times the reference concentrations.

Histopathological analyses revealed the presence of liver abnormalities that were significant in terms of number in Tidal Bay compared to the reference area. The incidence of liver lesions was greatest in fish from areas with the highest concentrations of sediment-associated contamination.

Characterizing and Ranking Problem Areas

The original data from the toxicity tests, abundances, and biomarkers were used to evaluate the increases in contamination or negative effects to determine if these changes were statistically significant. They were also used to evaluate quantitative relationships among these variables. However, because single-chemical relationships between exposure and effects could not be established (that is, a one-to-one relationship could not be proved), two methods were used to characterize and express the ecological impacts:

1. **Biological Indicators.** Using both exposure (chemical concentration) and effects data (from toxicity tests, macroinvertebrate abundances, and biomarkers), investigators developed ratios between the effects in Tidal Bay and those found at the reference site, Shipshape Inlet. The ratios, or biological indicators, were used in describing the overall impact of contamination on the ecosystem.

2. **Apparent Effects Thresholds.** Because biological effects data were not available for all portions of the study area, a method was developed to estimate thresholds of chemical concentrations above which biological effects would be expected. These are called apparent effects thresholds. Threshold concentrations of contaminants were estimated using data generated from the amphipod mortality toxicity test, oyster larvae abnormality toxicity test, and macroinvertebrate abundances. These measurements were selected because of their sensitivity to sediment contamination, availability of standard test protocols, and ecological relevance. The apparent effects thresholds were compared with measured concentrations of sediment contaminants. The apparent effects thresholds indicate the potential for adverse ecological effects in Tidal Bay.

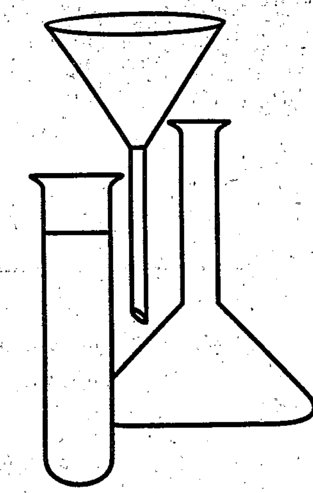
8. *Could apparent effects thresholds be determined for bioaccumulation and histopathology in fish? Why do you suppose investigators did not do this?*

9. *What are some major strengths of the apparent effects thresholds and what are some limitations?*

10. *Name one point you learned that you feel is most interesting.*

Activity 7

Identifying Risks at a Superfund Site



Duration	2 class periods
Grade Level	7-12
Key Terms/ Concepts	Exposure Hazard Ranking System Hazardous substance Hazardous waste National Priorities List Preliminary assessment Risk Site inspection Superfund
Suggested Subjects	Chemistry Earth Science Geology Physical Science

Purpose

This activity helps students understand the types of risks found at Superfund sites and how these risks are identified and assessed. They learn how sites are discovered and where to report potential hazardous waste sites. They discuss the activities undertaken by the government or other parties at hazardous waste sites to identify sources of contamination, determine the type and extent of contamination, and evaluate the risks posed to human health and the environment.

Background

The **Superfund** Program in the United States was created as a response to widely publicized contamination problems caused by hazardous waste. The Superfund law specifies a process for reporting potentially contaminated hazardous waste sites to the Federal government. The U.S. Environmental Protection Agency (EPA) and states investigate hazardous waste sites to determine the seriousness of the contamination. The most serious sites are cleaned up using Superfund authority. Some will be cleaned up by State governments, and some will require no cleanup because they pose no danger to people or the environment.

The extent of the hazards of **exposure** posed by each site discovered are assessed. Tied to the concept of exposure is the concept of **risk.** Risk is a measure of the probability of suffering harm or loss. For example, risk is used to measure the probability that a person will be exposed to a **hazardous substance** (like mercury) and the chances that the exposure will harm the person's health. Environmental risk is a measure of the probability that hazardous substances will harm the environment.

There are two types of risks associated with hazardous substance contamination. The *risk of exposure* is a measurement of the probability that being near a hazardous substance will lead to exposure of a person or the environment. The *risk of injury* after exposure depends on the toxic or other harmful effect associated with the particular contaminant.

For more information on risk identification, see the Suggested Reading list found at the end of the Haz-Ed materials. Other Haz-Ed materials that are related to this topic include *Warm-Up 4: Risk Concepts* and *Fact Flash 9: Common Contaminants.*

Preparation

1. Gather the following materials:

   - Copies for each student of:
     Fact Flash 1: Hazardous Substances and Hazardous Waste
     Fact Flash 2: The Superfund Cleanup Program
     Fact Flash 3: Flowing Railroad Hazardous Waste Site

   - Copies for each group of:
     Student Handout, *The Preliminary Assessment and Site Inspection for the Flowing Railroad Site*

2. Read the Fact Flashes to prepare your lecture. Also refer to Warm-Up 4 for information on risk and probability in relation to Superfund sites.

3. Distribute Fact Flashes 1, 2, and 3, and have students read them for homework.

4. OPTION: As extra-credit homework, give several students library assignments to look up one of the important concepts or contaminants included in Fact Flash 3. For example:

   - Superfund
   - Asbestos
   - TCE
   - PCB
   - Point Source
   - Nonpoint Source.

   Some information can be found in *Fact Flash 9: Common Contaminants.* Instruct each student to be prepared to make a short report on his or her research at the beginning of the next class on identifying risks.

   If you do not assign these reports as extra credit homework, you may want to gather some information yourself to present to your students at the first class.

Procedure

Class #1

1. Have each student assigned extra-credit homework make his or her report to the class, or present information on these topics yourself.

2. Allow students to ask questions and discuss the information to help prepare them for Class #2.

Class #2

1. Briefly review the main points from Fact Flashes 1, 2 and 3. An Instructor Fact Sheet, *Information Highlights on the Flowing Railroad Site*, is included at the end of this lesson for your use.

2. Ask students how contaminants might spread from the hypothetical site. Possible answers include:

   - The wind can blow contaminant vapors
   - The wind can blow small soil particles to which contaminants are attached
   - Contaminants can be washed into the Flowing River by rainfall running off the site
   - Liquid contaminants can flow down through the soil to the groundwater
   - Contaminants can be washed down through the soil to the groundwater by rainfall
   - Groundwater moving underground can spread contaminants in the aquifer
   - Contaminated groundwater can move into the Flowing River
   - Surface water sediments can be washed downstream, particularly during floods.

3. Ask students how animals or plants might be exposed to contaminants from the site. Possible answers include:

   - The wind can blow contaminants to tree leaves, grasses, or crops
   - Animals can eat contaminated plants
   - Fish and aquatic plants can be exposed to contaminants washed into the Flowing River
   - Farmland crops could be exposed to contaminants through irrigation from the Flowing River.

4. Ask students how people in Ruralville and Utopia might be exposed to contaminants from the site. Possible answers include:

   - Eating contaminated crops
   - Eating contaminated fish from the Flowing River
   - Utopia residents drinking contaminated water from their municipal wells
   - Ruralville residents drinking contaminated water from the Flowing River
   - Children playing on the site
   - Fishermen crossing the site to get to the Flowing River
   - Ruralville residents breathing contaminated air blown off the site
   - Ruralville and Utopia residents taking showers with contaminated water.

5. Ask students to name some factors that are important to consider in determining the risk of exposure to site contamination. Possible answers include:

   - Amount (volume) of contamination originally released at the site
   - Concentration of the released contaminants
   - Degree of dispersion (dilution) of the contaminants (more dispersion equals less risk)
   - Frequency of contact with contaminated water, soil, plants, and animals
   - Amount of physical, chemical, and biological transformation of the contaminants into a harmless state (degradation, containment).

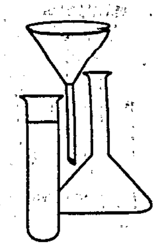
6. Distribute the following Student Handout, *The Preliminary Assessment and Site Inspection for the Flowing Railroad Site*. Divide the class into groups of 5 or 6 and instruct each team to choose a spokesperson.

7. Have each group discuss and answer the questions listed on the handout. After about 10 minutes, have the class reassemble and have the spokesperson for each team present the team's responses.

8. Record the responses and discuss any differences between the groups. Why does EPA focus on these questions when investigating potential hazardous waste contamination? Does the class believe direct contact is more serious than food chain contamination? Is human health protection more critical than protection of sensitive environments?

Extension (Optional)

- Consider inviting an EPA or State Remedial Project Manager (RPM) involved in overseeing hazardous waste cleanup projects at a site in your state to discuss how risks at that site were identified and assessed. Also ask the speaker to discuss the steps taken to put the site on the NPL or other priority list.



Instructor Fact Sheet — Information Highlights on the Flowing Railroad Site

FRR Enterprises is the parent company that owns Flow Automations (currently operating) and the Flowing Railroad (no longer operating).

The Flowing Railroad site is an inactive train yard where locomotives were repaired and maintained.

The Flowing River borders the site to the east. It supplies fish that nearby families eat 3 to 4 times a week and feeds the aquifer that supplies drinking water and irrigation to homes, businesses, and farms (municipal wells and the irrigation intake are 3 miles downstream from the site).

8,000 people live within 1 mile of the site and 1,400 people live within 1/4 mile.

Contaminants identified by EPA sampling include:

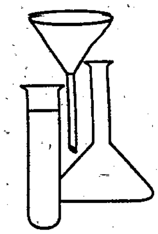
- Lead, zinc, and copper wastes, which result from building locomotive cars;
- PCBs, which can be released if electric power transformers are punctured; and
- TCE, a volatile organic compound, probably used to degrease and clean locomotive parts.

The potential for contamination of the Flowing River and other surface water and groundwater (e.g., the aquifer) could be increased by rain and melting snow washing through contaminated areas.

Samples from a shallow well drilled at the site contained lead and a high concentration of TCE, but the actual extent of the contamination is unknown. The soils in a few areas of the site have been contaminated; full tests of the soil have not been conducted.

Community concerns include:

- Potential release of asbestos, which could contaminate the air
- Peculiar, noxious odor from drinking water faucets in Ruralville
- Possible health impacts for people who regularly eat potentially contaminated fish
- Potential impacts on the health of people who breathe in TCE fumes
- Reported increase in the number of cancer cases in the surrounding areas
- Potential environmental and economic impacts on soil and crops contaminated by irrigation water
- Future use of the site property
- Potential economic impacts on Ruralville if FRR Enterprises had to lay off workers or close Flow Automations if the company cannot afford the cleanup costs.



The Preliminary Assessment and Site Inspection for the Flowing Railroad Site

Discuss within your group the following questions about the Flowing Railroad site. The only information you have about the site is contained in the fact sheet you just read. Your group should answer these questions (space is provided after each question) and select a spokesperson to present your answers.

1. What are your biggest concerns regarding the site and why?

    - *Health concerns (e.g., cancer, neurological disorders) from drinking polluted water, food chain contamination, or breathing air contaminated by the site?*

    - *Environmental resource concerns, including fish in the Flowing River?*

2. What are the ways in which the contamination can spread? (These are commonly referred to as "routes of migration.")

    - *Melting snow?*
    - *Rain?*
    - *Humans trespassing on the site?*
    - *Fish?*
    - *Wind?*

    Are there other ways?

3. How would you rank the threats to human health and the environment from this site? Choose from the list of threats below, or come up with your own. What is the rationale for your ranking of the threats?

- *Groundwater, the source of drinking water for the neighboring Town of Ruralville and the nearby City of Utopia?*
- *Flowing River, which serves as a source for irrigation and municipal wells, in addition to recreational and subsistence fishing?*
- *Soil?*
- *Air and wind?*

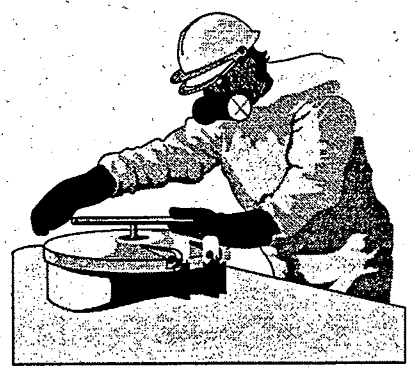
4. What actions could be taken now?

- *Put up a fence?*
- *Provide drinking water?*

Are there others?

Activity 8

Hazardous Waste Cleanup Methods



Duration	1 class period
Grade Level	9-12
Key Terms/ Concepts	Cleanup method Treatment technologies
Suggested Subjects	Biology Chemistry Civics/Government Life Science Physical Science Physics

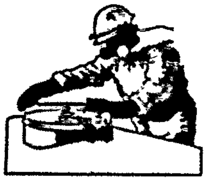
Purpose

This activity helps students understand some of the reasoning and science involved in choosing technologies for cleaning up hazardous waste sites. The students analyze the pros and cons of using various technologies for cleaning up specific hazardous waste problems, weighing factors such as contaminant-specific requirements, technological limitations, reliability, cleanup time, and cost.

Background

The Superfund Program was established by Congress in 1980 in response to growing public concern over the health and environmental risks posed by hazardous waste sites and other uncontrolled toxic hazards. The law is formally called the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA). The U.S. Environmental Protection Agency (EPA) administers the Superfund Program in cooperation with individual states and Tribal governments. EPA is responsible for responding to chemical emergencies and investigating and cleaning up uncontrolled or abandoned hazardous waste sites throughout the United States.

In the Superfund Program, EPA uses a variety of processes and technologies, alone or in combination with each other, to clean up hazardous waste sites. Some processes are designed to physically remove the contaminated material from the site or confine contaminated materials to a specific area. Other processes and technologies are designed to treat the contaminated material—to destroy or permanently change their chemical structure; to extract or separate them from the soil, sludge, sediments, or the water they are contaminating; or to immobilize them and keep them from moving or spreading beyond the site.



The responsibility for selecting the most appropriate **cleanup method** for a specific site rests with the EPA Remedial Project Manager (RPM) or On-Scene Coordinator (OSC), with input from the affected community. An important step in this selection process is narrowing the field of alternatives and developing a list of options that make sense for dealing with the contamination at the site.

The RPM or OSC has to examine the range of available technologies and processes and find the ones that offer the best potential for reaching the cleanup goals that have been set for the site. This involves weighing several factors—whether a technology is capable of effectively treating the contaminants present at the site, how long it will take to clean up the contamination using the technology or process, how much it will cost, how complicated or difficult it is to use, and if it is safe for both the workers at the site and the surrounding community.

Many processes and **treatment technologies** are available for use at hazardous waste sites, and new technologies are constantly being developed. The state-of-the-art is changing continuously. For convenience, this activity is based on current information about the most commonly used technologies at Superfund sites.

For additional information on the topics covered in this activity, see the Suggested Reading list found at the end of the Haz-Ed materials.

Preparation

1. Gather the following materials:

   - Copies for each student of
     Fact Flash 3: Flowing Railroad Hazardous Waste Site
     Fact Flash 4: Flowing Railroad Site Investigation Results
     Fact Flash 8: Common Cleanup Methods
     Fact Flash 9: Common Contaminants.

2. Read the 4 Fact Flashes to prepare your lecture.

3. Distribute Fact Flashes 3, 4 and 9. Have students read Fact Flashes 3 and 4 for homework. They can get more information about the contaminants at the site in Fact Flash 9.

Procedure

1. Review the information in Fact Flashes 3 and 4 with the class.

2. Ask students to identify the contamination problems at the site. (Answers should include TCE, metals, PCBs, asbestos in the soil, and lead and TCE in groundwater.)

3. Divide the class into teams. Have each team discuss the options below and decide how the site should be used in the future:

   A. Should the site become a park, residential area, school, or playground?

   B. Should the site remain a restricted area for limited industrial use only?

   C. Should the site be zoned for a landfill or for hazardous waste storage since it already has been polluted?

4. Have each team record their decision on a sheet of paper.

5. Distribute copies of *Fact Flash 8: Common Cleanup Methods.* Have teams choose the one or two **cleanup methods** (from those listed in the Fact Flash) that would be most effective in protecting human health and the environment <u>now</u> and that make sense in light of their decision about the site's <u>future use</u>.

6. Instruct teams to discuss and record on a sheet of paper the reasons for their selections.

7. Reassemble the class and have students discuss and compare the various teams' selections.

Activity 9

Making Decisions About Hazardous Waste Cleanup

Duration	3 1/4 class periods
Grade Level	9-12
Key Terms/ Concepts	Cleanup Hazardous waste Potentially Responsible Party Superfund
Suggested Subjects	Health Life Science Physical Science Social Studies Drama Civics/Government

Purpose

This activity lets students assume roles and act out a situation that illustrates the process of decision making related to cleaning up a Superfund site. Students identify the participants in the Superfund decision making process, make judgments about the potential effect of site cleanup on the characters they portray, and learn that different people have different perspectives on the same cleanup issues. In addition, they practice writing statements, formulating questions, and articulating their views in a public meeting setting.

Background

Whether we are children or adults, our lives are influenced by a constant series of choices. Some choices we make for ourselves. Some are made by parents for their children, and many are made by people we don't even know. The combination of all these choices determines the quality of each of our lives. Making these choices is not easy because sometimes what one person perceives as the right choice for him or her as an individual may be perceived as the wrong choice for the neighborhood, community, or country.

For example, people living near an abandoned **hazardous waste** site may want the site cleaned up as fast as possible, no matter what the cost, because they fear for their own, as well as their children's, safety. On the other hand, people employed by a company that caused the contamination at the site (a **Potentially Responsible Party**) or the local government may favor alternatives that, while effective, take longer and cost less. They are concerned about the impact on jobs and the local economy if the government requires the company to pay too much for the **cleanup**.

The process of making decisions about **Superfund** site cleanup involves weighing and balancing a variety of technical and nontechnical factors, including the sometimes competing interests in the community. This activity provides a lesson about Federal policy-making that extends well beyond the Superfund Program.

To help prepare your students for this activity, use *Warm-Up 5: Hazardous Waste Issues in the News.* You may perform the entire Warm-Up or simply review the main points covered in it. As a follow-up, have your students perform *Activity 11: What the Community Can Do.*

For additional information on these topics, see the Suggested Reading list found at the end of the Haz-Ed materials. Other Haz-Ed materials that are related to this topic include *Fact Flash 8: Common Cleanup Methods* and *Fact Flash 10: Superfund Community Involvement Program.*

Preparation

1. Gather the following materials:

    - Copies for each student of Student Handout, *Analysis of Alternatives for Cleaning Up Flowing Railroad Site*
    - The *Character Background Sheets* included at the end of this lesson
    - Copies for each student of:
      Fact Flash 2: The Superfund Cleanup Program
      Fact Flash 4: Flowing Railroad Site Investigation Results.

Procedure

Class #1

1. Explain to students that in two successive follow-up sessions the class will act out a situation that illustrates the sometimes difficult process of making decisions about Superfund site cleanup. For this role-playing exercise, students will assume they live in the hypothetical area of the Flowing Railroad Superfund site. They will participate in a community meeting held to discuss and air community views about the site cleanup options under consideration.

2. Divide the class into nine teams. Explain that each team will represent one of the "players" in this drama: the U.S. Environmental Protection Agency's (EPA) **Remedial Project Manager (RPM)**, EPA's **Community Involvement Coordinator (CIC)**, a local Health Department official, the Mayor of Ruralville, the attorney for

FRR Enterprises, a local environmental activist, a person employed at Flow Automations, Inc., a local farmer, and a local carpenter.

NOTE: If you live in a community near a real Superfund site, you may choose to prepare Student Handouts using information about that site so the role-play will be more realistic for your students. Call the Community Involvement Coordinator in your state. Phone numbers are provided at the end of the Haz-Ed materials.

3. Assign a role to each team and explain that later each team will have to choose 1 team member to be the actor when the first part of the drama is played out at the next class. Team members should prepare a written statement for their character to deliver, as well as a list of questions the character may want to ask at the meeting.

4. Distribute the Student Handout, *Analysis of Alternatives for Cleaning Up Flowing River Site*. Give each team the *Character Background Sheet* that is appropriate for its assigned role. *NOTE: If you live in a community near a Superfund site, you may choose to adjust the roles and the background information for each to approximate the makeup and situation in your community.*

5. Distribute Fact Flashes 2 and 4. Explain to students that these Fact Flashes can be used as background information.

6. Explain that the information on these handouts can be used to develop their character's beliefs, attitudes, and point of view about the cleanup. Stress that this should go beyond what the character knows or has heard and should include identifying questions the character wants to ask about the cleanup. Encourage students to talk to their parents, local city or town government officials, business owners, and others to help develop their perspectives. Also remind students that some of their characters—EPA's RPM and CIC, the Mayor, and the official from the local Health Department, and possibly others—would probably consult with each other in real life to prepare for the meeting. Encourage teams responsible for these characters to do so.

7. Specify a specific date for the next class, allowing several days for preparation.

Class #2

1. For the role-play activity, have the students representing the Mayor and the CIC arrange desks or a table at the front of the room with chairs to accommodate 4 people, the Mayor, EPA's CIC, RPM, and the moderator/facilitator. Place a lectern, desk, or small table somewhere else in the room from which the other characters will make their statements.

NOTE: You may wish to assume the role of moderator/facilitator yourself or you can select a student to do so. The moderator/facilitator's only responsibilities are to maintain order, see that everyone has an opportunity to speak, direct questions to the appropriate person to answer, and see that people speak in turn rather than all at once.

2. At the conclusion of the meeting, explain to the students that the teams playing EPA's RPM and CIC will get together and consider the information presented in this meeting, make a decision, and present a Proposed Cleanup Plan at the next class (specify the date, allowing sufficient time for the RPM team to meet and prepare a plan). Students from the other teams will have an opportunity to discuss the decision among themselves and comment on it.

3. Have the Mayor speak first to welcome people to the meeting, then EPA's CIC. After that, have others (the assigned characters) raise their hands to be recognized as they would in a real meeting and call on them in turn. After all participants have made their initial statements, the various characters may be recognized to ask follow-up questions or make additional observations as often as time permits.

Class #3

1. Have the spokesperson for the RPM team present the team's Proposed Cleanup Plan, including the rationale for choosing the selected remedy. Allow no more than 10 minutes for this presentation.

2. Give students about 10 minutes to discuss the decision with their team members. Offer the teams an opportunity to comment on the decision. Is the decision clear? Do they agree with it? Why or why not? Do they understand the RPM team's rationale in making the decision?

3. After teams have made comments from the perspective of their characters, invite the class as a whole to discuss the role-play and the decisionmaking process illustrated. What were the various points of view expressed in the meeting? Which were similar? Which were different (competing)? Which would you have expected to carry more weight? Why? Did those points of view appear to influence the final decision? How do you think the decision will affect the quality of life in the community? Now that the decision has been made, do you think all the characters in this drama will accept it? Why or why not? What options do they have if they do not accept it? *(NOTE: An Instructor Fact Sheet,* Highlights about Roles, *is included in this lesson to help you ensure that the perspectives of all characters in the role-play are covered during the discussion.)*

Extension (Optional)

- Have students bring in examples throughout the year, from newspaper or local television news, of real Superfund cleanup or hazardous waste prevention decisions made by your local government or a major local business. Set aside time periodically to discuss the choices involved in these decisions and their impact on the quality of life in the community. *Warm-Up 5: Hazardous Waste Issues in the News* contains sample articles of the type students may find.

Instructor Fact Sheet – Highlights about Roles

NOTE: You may need to begin the discussion by identifying 1 or 2 of the actors' perspectives; try to make sure that perspectives of all the characters are covered during this discussion, encouraging the participants to identify as many as possible. You may want to write students' responses on the blackboard, or on a flip chart if you have one, to illustrate the range of perspectives presented and reinforce the idea that the decisionmaking process involves weighing and balancing many different, and sometimes competing, points of view.

- The **RPM** wants to learn more about the citizens' concerns so s/he knows what they are and how they can be addressed by the cleanup of the site and reflected in various written reports and other methods (e.g., fact sheets).

- The **CIC** also wants to learn more about the community's concerns, so s/he can begin identifying the kinds of information the community is seeking and ways it can be provided to them.

- The **local health official** wants more information about potential health hazards the community will be exposed to; the health official also sees this as an opportunity to increase his/her standing in the community.

- The **Mayor** of Ruralville has multiple perspectives. The mayor is concerned about the health and safety of the citizens and wants answers to questions. The mayor is also concerned about Ruralville's economic growth; its ability to attract future business; the danger of losing a major employer if FRR Enterprises goes bankrupt as a result of paying for cleaning up the site; and his/ her own reelection.

- The **attorney** for FRR Enterprises wants to protect his/her client's interests. If FRR Enterprises is being damaged financially due to incorrect or overly cautious studies, or is being asked to conduct site activities that go beyond reasonable measures for cleaning up the site, the attorney wants to know this so s/he can take action on behalf of the company.

- The local **environmental activist** is genuinely concerned about improving the environment and asks some very informed and appropriate questions in search for more information.

- The **plant worker** is worried about job security, as well as his/her family's health and safety.

- The **farmer** depends on the water from the Flowing River to irrigate the farm. The publicity surrounding this situation has already caused customers to be alarmed. The farmer wants to know exactly how serious this situation really is and how s/he can protect his/her farmland and economic future.

- The **carpenter** is concerned that the needs of poor people in the community won't be considered as decisions about the site are being made.

Analysis of Alternatives for Cleaning Up Flowing River Site

Alternative	Brief Description	Advantages	Disadvantages
#1 Provide Security	This alternative is used as a baseline against which to compare other alternatives. It allows for continuous monitoring of site conditions; action can be taken if conditions change. It includes fencing the contaminated area and erecting signs to indicate potential health hazards.	Because no threat to drinking water exists (the deep aquifer is not connected to the shallow aquifer), funds for this site may be used for more hazardous sites. The fence prevents direct contact with contamination.	It does not address the contamination. Contaminated water may continue to move toward the Flowing River. Asbestos particles may be released during windy weather if erosion continues to occur. The site is not available for future use.
#2 Only Cap	This alternative places layers of waterproof material like clay and plastic over the contamination. It reduces the amount of water reaching the contamination, and the contamination is slowed from moving and reaching water sources.	A short period of construction is required, so the site is addressed quickly. This technology is inexpensive, reliable, and commonly used. It will last with proper maintenance. The cap will reduce the rate at which the contamination in the shallow aquifer will move toward the Flowing River.	The cap does not neutralize or eliminate contamination. The cap requires maintenance and monitoring and is not always 100% effective. It limits the site's reuse; in order to maintain the cap, nothing can be built on top of it.
#3 Cap, Air Stripping, Chemical Precipitation	This alternative uses a cap to address soil contamination, as described in Alternative #2. Air stripping and chemical precipitation of contaminated water requires building a large tower on the site and drilling wells into the aquifer. Contaminated water is pumped to the top of the tower where the volatile pollutants can evaporate and form a gas. The gas is then filtered through a layer of carbon to remove the contaminants. After air stripping, the water is treated by chemical precipitation to remove the heavy metals. Chemicals are added to the water to create a sludge. The water is filtered from the sludge, treated, and pumped back into the environment. The sludge is sent off site to a licensed disposal facility.	The cap addresses the asbestos. See discussion of capping advantages in Alternative #2. This technology effectively removes most of the contamination from the shallow aquifer over 2-10 years. Most of the contamination is addressed through treatment, without having to move it from the site. An air stripper is relatively easy to operate and is not technically complex. Metals and PCBs are captured in the sludge. A licensed off-site facility can contain the sludge through extensive controls.	See the discussion of capping disadvantages in Alternative #2. The air stripping tower needs to be monitored carefully to ensure that any contamination released into the air meets State standards. Air stripping is 90% efficient and the tower needs to be monitored to prevent releases of contaminants. Contaminated sludge needs to be disposed of properly offsite.

Analysis of Alternatives for Cleaning Up Flowing River Site (con't.)

Alternative	Brief Description	Advantages	Disadvantages
#4 Incineration, Air Stripping, and Chemical Precipitation	This alternative involves digging up and burning contaminated soils at high temperatures in an on-site incinerator. The incinerator destroys TCE and PCB contamination. The remaining ash containing heavy metals is shipped off site to a landfill. As described in Alternative #3, air stripping and chemical precipitation of contaminated water require building a large tower on the site and digging wells into the aquifer. Contaminated water is pumped to the top of the tower where some of the pollutants can form a gas that may be filtered through carbon. Heavy metals are removed from the water by chemical precipitation.	The site is "clean" and available for reuse. The incinerator destroys at least 99.9999% of the organic (burnable) contaminants in the soil. An air stripper is relatively easy to operate.	Stringent permits are required to operate an incinerator. Hazardous emissions from incinerators have been associated with health risks, so careful monitoring is required. Public resistance to incineration often occurs. Treatment residuals from the incinerator must be managed and disposed of. Air stripping is 90% efficient. The air stripping tower needs to be monitored carefully to ensure that any contamination released into the air meets State standards. Asbestos is not addressed.
#5 Complete Excavation	This alternative requires digging up a large volume of the contaminated soil and shipping it to an off-site hazardous waste facility. Groundwater contamination is treated on site with air stripping and chemical precipitation, as described in Alternative #3.	This technology removes contaminated soil completely in a short period of time and requires no future maintenance. An air stripper is relatively easy to operate and is not technically complex. The site is safe for future use.	Trucks that carry contaminated soil (and those that deliver clean backfill) drive through town. A risk that something could go wrong during the removal and export of soil exists, which could result in public exposure to the contaminants through the air. Concerns may be raised over odor caused by excavation and transporting contaminated soil. Contamination is not addressed or treated on-site, but is passed elsewhere. Dust from excavation activities must be controlled. Roads may need to be repaired.

Character Background Sheet

EPA Remedial Project Manager (RPM)

You are the RPM assigned to the Flowing Railroad site. Your job is to direct the response effort and coordinate all cleanup activities at the site. You are responsible for coordinating not only with EPA Regional and Headquarters staff, but also with other Federal, state, and local agencies.

Although you live and work in the city where the EPA Regional Office is located, many of the sites for which you have been responsible were in small towns and rural areas like this one, so you can empathize with the concerns of the citizens of Ruralville. Your purpose at the community meeting is to tell people about the investigation of the problems at the site and the sort of cleanup options you are weighing as a result. In addition, you want to give them the opportunity to ask any questions and express any concerns they have about the cleanup in general or about specific cleanup options.

When the meeting is over, you will have to make a final decision about how to recommend that the site be cleaned up, balancing the data from your investigation and the other information at your disposal with what you hear in the meeting about what the community thinks. This is not an easy decision to make, because there are a lot of needs and interests you must try to satisfy—the requirements in the law, the needs of the people who live in the community, the wishes of those who run businesses in the community, the interests of FRR Enterprises which is a major employer in the community, etc.

You are responsible for choosing a cleanup option that:

1. protects human health and the environment
2. complies with existing Federal and state laws and requirements

Your choice also must:

1. be effective in the short-term, as well as over the long-term
2. reduce the toxicity, mobility, or volume of the contaminants
3. be realistic
4. be reasonably cost-effective
5. be acceptable to the community

You will prepare a Proposed Cleanup Plan describing your decision and discussing why you chose to proceed in this way. You will have to present that plan to the same group of people from the community and hear their reactions.

Character Background Sheet

EPA Community Involvement Coordinator (CIC)

You are the CIC assigned to the Flowing Railroad site. Your job is to manage all EPA's community involvement activities to provide an opportunity for public participation in the Superfund process.

You grew up in Ruralville but left to go to college. Now you live in the city where EPA's Regional Office is located. You still know a lot of people in Ruralville, and you are eager to help them understand what's involved in cleaning up the site and how the cleanup will—and will not—affect their lives.

Your purpose at the community meeting is to help explain the cleanup options being considered, answer citizens' questions, and listen to community concerns. You have already met most of the people at the meeting because your overall responsibility has been to ensure that the community knows what to expect and how to participate in Superfund decisionmaking. You have been sharing information about the Superfund process with the community and obtaining information from them since EPA's activities at the site began. You've visited with individuals, families, and business owners in the community, written fact sheets about various stages in the process, gathered and distributed information about the site itself and the data EPA collected during its investigation of the site. When the meeting is over and the RPM has made a final decision about how to clean up the site, you will prepare a fact sheet that summarizes the decision and help the RPM respond to comments from the community about the selected cleanup strategy.

You lead the meeting for EPA.

Character Background Sheet

Local Health Official

You are a Health Advisor for the Ruralville Health Department. Although you have more than 10 years of experience in the health field, this is the first time you have encountered a situation involving a hazardous waste site.

Your purpose at the community meeting is to learn as much as possible about any potential health effects that could result, now or in the future, from contamination at the site and from efforts to clean it up. You need this information to be able to accurately advise townspeople of any health-related dangers and how to avoid them.

Character Background Sheet

Mayor of Ruralville

You have been Mayor of Ruralville for six years. Your job is to protect the health and welfare of the community and its citizens and to make sure the interests of the community are considered as Superfund decisions are made.

You are a well-respected member of the community. Most of the townspeople believe you have done good things for Ruralville. Your purpose at the meeting is to demonstrate the leadership residents expect from their Mayor and to ensure the continuing economic well-being of the community, as well as the safety of its citizens.

You support town growth and have helped several small businesses get established in the community. Some people credit you with being instrumental in Flowing Railroad's decision to open its Flow Automations factory in Ruralville. The factory employs many of the people who work in Ruralville. In fact, some of them originally worked for the Flowing Railroad and were retrained so they could work at the new factory.

Your family is very important to you. You are especially close to your oldest child who happens to be married to the president of Flow Automations.

You lead the meeting.

Character Background Sheet

Attorney for FRR Enterprises

You are the general counsel for FRR Enterprises which owns the Flowing Railroad Company site and Flow Automations. Your purpose at the meeting is to protect the company's interests. You want to make sure the government and individual residents realize how the cleanup decisions in this case will affect the company and, in turn, the town's tax revenue and all the townspeople employed by the company.

You are concerned because FRR Enterprises already has spent more than $1 million on studies required to determine the extent of contamination at the site, and more bills are on the way. FRR Enterprises also will have to bear much of the cost of any cleanup remedy selected. You want people to understand that the contamination at the site resulted from activities that were legal at the time. You intend to argue that to make the company bear the financial burden for that is unfair, because the company did not do anything wrong. Besides, the Flowing Railroad was not the only business operated on the site, and if FRR Enterprises has to pay, even though they did nothing wrong, so should all the other businesses who operated on the site. FRR should not be penalized just because it is still around.

Although FRR Enterprises is financially stable now, company officials—your bosses—are concerned about the long-term impact of the cleanup since it is hard to predict what the total cost will be.

Character Background Sheet

Local Environmental Activist

You are a resident of Ruralville and the founder of the local chapter of Everlasting Earth. Everlasting Earth is a national advocacy organization dedicated to preventing pollution and fighting threats to public health and the environment. You are passionate in your belief that polluters should pay to clean up the problems they create.

Your purpose at the meeting is to make sure that no one lets FRR Enterprises off the hook. You believe they have damaged the environment and, as a result, the health of community residents could be in danger. You were one of the first people to learn (from your friend at the bank) about the environmental audit of the Flowing Railroad site. As soon as you heard the consulting firm's findings, you began lobbying to get the town to demand the site be cleaned up; you want the most stringent cleanup standards applied in this case.

You do not believe the town should be concerned with how much the cleanup might cost; FRR Enterprises must be made to pay, no matter what the cost. You also do not believe there is any danger that FRR Enterprises could go bankrupt or that Flow Automations could go out of business as a result of paying for the cleanup. You think the company is just trying to scare people.

Character Background Sheet

Worker at the Flow Automations Factory

You are employed as an assembler at the Flow Automations factory. Prior to this job, you worked for the Flowing Railroad.

Your purpose at the meeting is to learn as much as you can about the problems at the site and the cleanup being proposed. You feel like you are being asked to choose a "side" on this issue but you are confused. You have a number of concerns about the situation but no one answer seems to satisfy them.

You are a single parent with three young children. On the one hand, you need your job at Flow Automations; you have no other source of income. Besides that, Flowing Railroad was good to you; the company got you the job at Flow Automations and paid for the training you needed to do it. On the other hand, you and your children live near the site and you have the children's health and well-being to consider.

Character Background Sheet

Owner of a Farm near the Flowing River

You own 75 acres of farmland, some of which borders the Flowing River. The farm has been in your family for generations.

Your purpose at the meeting is to get some straight answers about the contamination from the site and how far it has spread. You want to know if it is affecting your crops and what can be done to stop it. You grow several crops and sell them to supermarkets in Ruralville and in several towns throughout the state. You depend on sales to stay in business and to pay your employees.

Your farm has had a number of hardships over the years. First, you lost many of your crops to a severe drought 2 years ago. Then, an electrical storm last June started a fire that burned several acres before it could be stopped. These things have cost you a lot of money. Now, some of your customers are asking you if your crops are contaminated because of what's happened at the Flowing Railroad site.

You feel like your farm's reputation and your whole future is at stake. You intend to let the Mayor and the people from the government know that and demand that they do whatever is necessary to solve the problem.

Character Background Sheet

Local Carpenter

You, your spouse, and your 4 children have lived in a rented cottage on the banks of the Flowing River for about a year. The Long Shot Cafe, where your spouse worked as a bartender, closed several months ago. Your spouse has not been able to find another job, so you have been the sole supporter for the family.

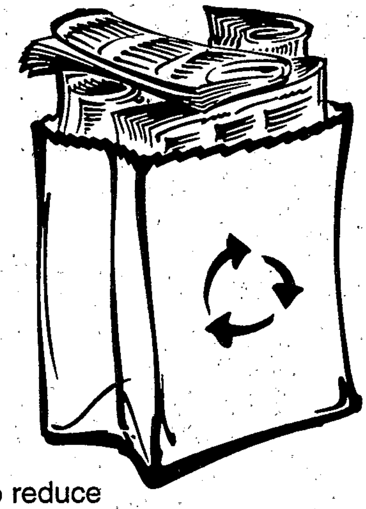
You earn money by doing odd jobs around town, but there haven't been many lately. You've had to depend on fishing in the river to feed your family; 3 of 4 main meals a week over the last few months have come from the river.

You have become increasingly frightened and angry over the last few weeks as you have heard more and more rumors about possible contamination of the river. You are convinced that, because you and your family are poor, your welfare will not be considered as the government makes decisions about how to deal with the Flowing Railroad site.

Your purpose at the meeting is to make them listen to your concerns.

Activity 10

Pollution Prevention



Duration	2 class periods
Grade Level	7-12
Key Terms/ Concepts	Corrosive Hazardous waste Ignitable Pollution prevention Reactive Solid waste Toxic
Suggested Subjects	Chemistry Civics/Government Mathematics Physical Science Social Studies

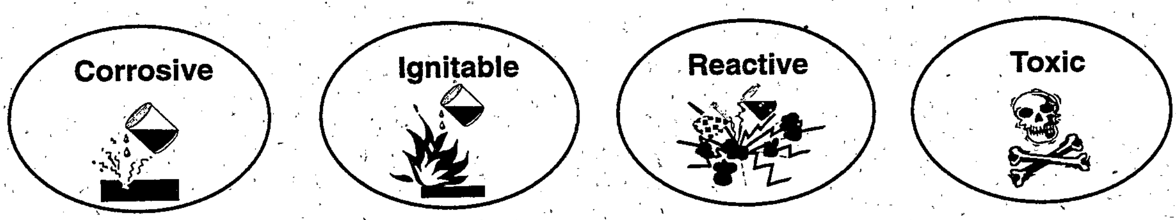
Purpose

This activity helps students understand what can be done to reduce the amount of solid and hazardous wastes that must be disposed of. Students review the characteristics of hazardous waste and develop an estimate of the amount of household hazardous waste in their community.

Background

Pollution prevention is any effort to reduce or eliminate pollution and wastes. Efforts can include reducing the release of pollutants to the air, reducing runoff into streams, preventing releases of hazardous chemicals, and decreasing the volume of **solid** and **hazardous wastes** we produce. This activity focuses on preventing pollution by reducing solid and hazardous wastes.

Hazardous waste is defined as any material that presents a threat or unreasonable risk of injury to people or the environment when it is produced, transported, used, or disposed of. Hazardous waste is categorized into four groups based on its characteristics:



By far the most hazardous waste is produced by industries and manufacturing. We also produce some hazardous waste in our homes when we do not properly dispose of items like worn-out batteries, paint products, cleaning agents, used motor oil, pesticides, and fertilizers.

NOTE: Even though industrial processes generate most hazardous waste, this activity focuses on hazardous materials found in homes because students can collect information on these materials more readily. Ideas for activities that focus on pollution prevention efforts in industry are included in the Extensions listed at the end of this lesson.

Warm-Up 1: Defining Hazardous Waste is good preparation for this activity. For more information on pollution prevention, see the Suggested Reading list found at the end of the Haz-Ed materials.

Preparation

1. Gather the following materials:

    - Copies for each student of *Fact Flash 7: Pollution Prevention*
    - Copies for each student of the Student Worksheet, *Hazardous Substance Data Collection Form*
    - Copies for each student of the Student Handout, *Chemicals in the Household.*

2. Read Fact Flashes 1 and 7 to prepare your lecture.

3. Distribute Fact Flash 7 and have students read it for homework.

Procedure

Class #1

1. Discuss pollution prevention in class using the contents of *Fact Flash 7: Pollution Prevention.*

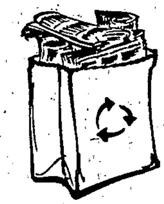
2. Review with students the definition and categories of hazardous waste. Ask the students for examples of products in their homes that fall within each of the 4 hazardous waste categories.

3. Distribute the Student Worksheet, *Hazardous Substance Data Collection Form.*

4. Give students a homework assignment to identify all of the hazardous materials found in their homes and record the following information on the Student Worksheet:

    - The name of the product
    - The use of the product
    - Hazardous waste category of the substance (toxic, reactive, ignitable, corrosive—read label for information)
    - Estimated volume of the material remaining in the container.

    Note: Have students tell their parents about the assignment before they start the activity. Caution them not to touch any of the substances or open the containers.



Class #2

1. Ask the students what kinds of hazardous substances they found in their homes.

2. On the chalkboard, compile a list of products in each category found in the students' homes.

3. Explain to the students that their homes will be used as a sample of the homes in the community, and that the sample will be used to estimate the total amount of hazardous substances in all the homes of the community.

4. Have students calculate the number of gallons (or liters) of each category of hazardous substances they have reported in their homes (1 fluid ounce equals 30 milliliters, 0.26 gallons equals 1 liter).

5. Calculate a class-wide average of the amount of hazardous substances in each category.

6. Estimate the number of households in the community, using population information and assuming an average of 3.5 persons per household.

7. Have students multiply the class-wide average of hazardous substances in their homes by the number of homes in the community to estimate the total amount of hazardous substances in all of the homes of the community.

8. Discuss how much of each of these products might become hazardous waste—for example, by being thrown away in the trash or poured down drains that empty into the public water system. Discuss where these waste products end up.

9. Ask the students for ideas on what they personally can do to reduce the amount of hazardous waste. Ask them to name some alternative products that do the same jobs as products containing hazardous substances (for example, baking soda is an alternative to using commercial oven cleaners).

10. Distribute the Student Handout, *Chemicals in the Household.* Have students discuss the feasibility of changing people's habits and convincing them to use the alternatives on the list.

Extensions (Optional)

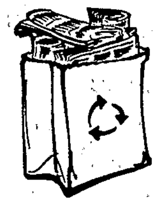
- Assign a group of students to identify the types and amounts of hazardous waste present in your school. Use the Student Worksheet to record the information they collect. Have them present their findings to the class and encourage the class to discuss ways in which the school could reduce its use of hazardous substances. Consider presenting these ideas to the school principal and the PTA.

- Have students contact the local health or environmental services department to investigate how much industrial garbage is collected and disposed of each year and what the community government is doing to deal with the potential hazardous waste problems this creates.

- Have students contact the local chamber of commerce, the county health department, or the local or state government environmental agency to obtain the names of local manufacturers and other businesses that have active pollution prevention programs. Have students interview officials at these companies about what they are doing to reduce waste and prevent pollution. As an alternative, invite local manufacturers and business owners to come to the class to discuss their pollution prevention programs. Local businesses that are working to reduce their wastes most likely would be quite happy to cooperate.

- Plan a field trip to a local **recycling** center or hazardous waste collection center. Check with the local chamber of commerce, or local or state government environmental agency to see if there is a household hazardous waste collection program in your area. More information on hazardous waste collection programs can be obtained by calling the RCRA/UST, Superfund, and EPCRA Hotline in Washington, DC, which is open Monday through Friday, 9:00 a.m. to 6:00 p.m. Eastern Standard Time. The national toll free number is 800-424-9346; for the hearing impaired it is TDD 800-553-7672.

- Consider showing a videotape describing pollution prevention. Check with your school or local librarian and with local public television stations for educational videotapes describing municipal, household, or hazardous waste management. For example the League of Women Voters of California's Education Fund produced two award-winning videotapes in 1990. *Cleaning Up Toxics at Home* and *Cleaning Up Toxics in Business* outline ways in which citizens and small businesses can significantly reduce pollution. Each tape is available for $29.95 ($49.95 for both) and may be ordered by calling The Video Project at 1-800-4-PLANET. Another video, called *The Rotten Truth*, was produced by the Children's Television Workshop for its *3-2-1 Contact* program. The video is available for $14.98, plus shipping and handling, by calling the distributor, Sony Wonder, at 1-800-327-3494.

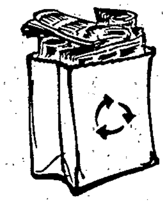


Hazardous Substance Data Collection Form

Product Name	Product Use	Hazardous Waste Category (toxic, reactive, ignitable, corrosive)	Estimated Volume Remaining

Hazardous Substance Data Collection Form

Product Name	Product Use	Hazardous Waste Category (toxic, reactive, ignitable, corrosive)	Estimated Volume Remaining



Chemicals in the Household

CHEMICAL PRODUCTS	HAZARDOUS INGREDIENTS	POSSIBLE ALTERNATIVES AND HINTS
Toilet Cleaners	Muriatic (hydrochloric) acid Oxalic acid Paradichlorobenzene Calcium hypochlorite	Toilet brush and baking soda; Mild detergent; Vinegar soak for tub and sink fixtures; Avoid direct skin contact and breathing of fumes.
Drain Cleaners	Sodium or potassium hydroxide Sodium hypochloride Hydrochloric acid Petroleum distillates	Plunger; Flush drain with 1/4 cup baking soda and vinegar; Avoid direct skin contact and breathing of fumes.
Oven Cleaners	Potassium or sodium hydroxide Ammonia	Baking soda and water; Avoid direct skin contact and breathing of fumes.
Bleach Cleaners	Sodium or potassium hydroxide Hydrogen peroxide Sodium or calcium hypochlorite	1/2 cup white vinegar or baking soda for laundry; Avoid direct skin contact and breathing of fumes.
Dishwashing detergent	Chlorine Surfactants	1 part borax to 1 part baking soda; Handle <u>all</u> cleaning solutions with care.
Ammonia-based cleaners (all purpose cleaners)	Ammonia Ethanol	Vinegar and salt water mix for surfaces; Baking soda and water.
Glass cleaners	Ammonia Naphthalene	Washing windows with 1/4 to 1/2 cup white vinegar to 1 quart warm water, rub dry with newspaper.
Fabric softener	Ammonia	1 cup white vinegar or 1/4 cup baking soda in final rinse water.
Air fresheners	Cresol Phenol Formaldehyde	Open box of baking soda or dish of vanilla; Simmer cloves; Open windows or use exhaust fans.
Laundry detergent	Surfactants	Avoid breathing powder.
Mothballs	Naphthalene Paradichlorobenzene	Cedar chips; Newspapers; Lavender, flowers, or other aromatic herbs and spices.

Chemicals in the Household (continued)

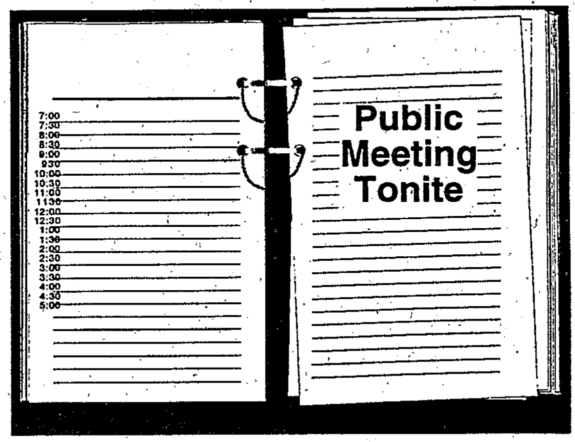
CHEMICAL PRODUCTS	HAZARDOUS INGREDIENTS	POSSIBLE ALTERNATIVES AND HINTS
Rug and upholstery cleaners	Naphthalene Perchloroethylene Oxalic acide Diethylene glycol	Baking soda or rug, then vacuum.
Floor and furniture polish	Diethylene glycol Petroleum distillates Nitrobenzene Mineral Spirits	1 part lemon oil, 2 parts olive/ vegetable oil; Vegetable oil soap.
Furniture strippers	Acetone Methyl ethyl Ketone Alchohols Xylene Tlouene Methylene chloride	Equal portions of boiled linseed oil, turpentine, and vinegar with steel wool; sandpaper or heatgun; Use in well ventilated areas or outdoors; Handle <u>all</u> solvents with care.
Stains/finishes	Mineral spirits Glycol ethers Ketones Halogenated hydrocarbons Naphtha Xylene Toluene	Natural earth pigment finishes; Use in well ventilated areas or outdoors; Handle <u>all</u> dyes and paints with care.
Enamel or oil-based paints	Pigments Aliphatic hydrocarbons	Water-based paints if appropriate; Always use in well ventilated areas.
Latex paint	Mercury	Handle <u>all</u> paints with care.
Antifreeze	Ethylene glycol	Clean up all spills.
Automobile batteries	Sulfuric acid Lead	Bring old batteries to recycling center; Avoid direct skin contact; Wash spills with plenty of water.
Automobile lubricants (transmission and brake fluids, used oils)	Hydrocarbons (benzene) Mineral Oils Glycol ethers Heavy metals	Seal used oil in plastic container and bring to recycling service station.

Notes

* The listed alternatives are offered as options and are not represented as recommended courses of action.
* Several listed alternatives are also potentially hazardous and can cause harm if handled improperly.
* Various commercial products which fall into the product categories listed here may not contain all of the listed chemical constituents.

Activity 11

What the Community Can Do



Duration	2 class periods
Grade Level	7-12
Key Terms/ Concepts	Administrative Record Community Involvement Information Repository Superfund Technical Assistance Grant (TAG)
Suggested Subjects	Social Studies Civics/Government Drama

Purpose

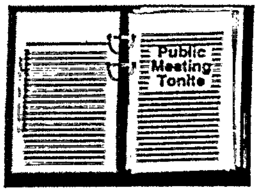
Students become familiar with how the U.S Environmental Protection Agency (EPA) tries to encourage communities near Superfund sites to become involved in the Superfund process. The types of activities communities can undertake to influence how hazardous waste sites are cleaned up are presented and discussed. Students become familiar with the different ways EPA encourages the community to get involved and the role of the local community in the Superfund process.

Background

Community Involvement is an essential part of all Superfund actions because the Superfund Program was established to protect the public's right to a safe, healthy environment free of dangerous hazardous waste sites. In addition to identifying the public's concerns and trying to address them, EPA and state and local environmental officials encourage groups of local citizens to become actively involved in determining the future use of contaminated sites.

EPA has always recognized the public's interest in hazardous waste management and its right to participate in the Superfund process. The law that created the Superfund Program requires a community involvement program at Superfund hazardous waste sites. This means that EPA must conduct specific activities to provide opportunities for public participation.

For more information on community involvement, see the brochure *This is Superfund* and the Suggested Reading list found at the end of the Haz-Ed materials. Other Haz-Ed materials that are related to this topic include *Fact Flash 2: The Superfund Cleanup Program* and *Activity 9: Making Decisions About Hazardous Waste Cleanup.*



Preparation

1. Gather the following materials:

    - Copies for each student of
      Fact Flash 3: Flowing Railroad Hazardous Waste Site
      Fact Flash 10: Superfund Community Involvement Program.

2. Read Fact Flash 10 and review *Activity 9: Making Decisions About Hazardous Waste Cleanup* to prepare your lecture.

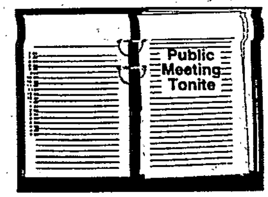
Procedure

Class #1

1. Begin the session by asking students who consider themselves "community activists" to raise their hands. Have a few of them explain what they mean by "activism" and why it is important to get involved in what goes on in the community. Also ask the students if any of them know of a Superfund site, and if so, whether they are familiar with EPA's public participation efforts and the community's response. If students volunteer some familiarity with the community involvement program or a site, have them share their knowledge with the class. The site may be local or may be one of the better known sites across the country.

2. Distribute *Fact Flash 10: Superfund Community Involvement Program.* Briefly review the opportunities for citizens to get involved in the Superfund Program and the examples of communities that have had a significant impact on the Superfund process.

3. Distribute *Fact Flash 3: Flowing Railroad Hazardous Waste Site.* Briefly review the main issues to be considered at the site. Explain that the class will be divided into groups for a role-playing exercise. Half of the groups will play the role of community residents near the site, and the remaining groups will assume the role of an EPA Community Involvement Coordinator (CIC). The Community Involvement Coordinator is responsible for developing, implementing, and managing EPA's community involvement and outreach activities at a site. Tell the students that each group will need to select a spokesperson and that the spokesperson will be expected to speak for about 5 or 10 minutes at a future class period about what their group decided to do in their role as an EPA CIC or as community residents.



4. Divide the class into groups and assign their roles. *(NOTE: The number of groups may vary, but each should include about 5 or 6 students.)*

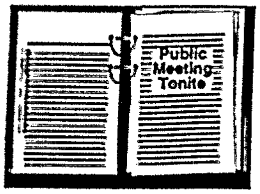
   - The groups playing community residents are to develop an "action plan" for influencing the cleanup decisions at the hazardous waste site. Their plans should identify activities they can undertake, as well as activities they would like EPA to undertake to inform them about what is happening at the site. Instruct the group to explain how they would implement the activity. For example, if they choose to form a task force to monitor EPA's activities and to make recommendations, the students must explain how they would form a task force, who would be a member, how often the task force would meet, and what issues it would address.

   - The groups playing an EPA CIC are to develop a community involvement plan that identifies steps that EPA will undertake to involve the community in site decisions and activities. Their plan should state the goals of the community involvement activities, the specific activities, and when the activities would be conducted. Remind this group that EPA is required to undertake certain activities by law. As part of this process, these groups will need to consider what information they can obtain from the community and how they can obtain this information. For example, they can interview residents door-to-door or ask residents questions at public meetings.

5. For the last 10 to 15 minutes of the period, tell the students to meet with their groups to discuss their assigned roles and tasks. Remind them that each group will give a 5- to 10-minute presentation on their assigned topic for the next class. The class period for the presentations should be scheduled 1 or 2 weeks after the initial assignment is made.

6. Encourage group members to discuss among themselves how best to accomplish the assigned task, make contact with appropriate sources of information, conduct interviews, compile information, structure a presentation, and prepare to answer questions posed by other students. Below are some resources the students could use:

   - **EPA Regional Community Involvement Coordinator (CIC).** By contacting the EPA Regional CIC for your state (see *This is Superfund* brochure), students can identify a nearby Superfund site or one within the state that they can research. Information can be collected from the Regional CIC or from a Superfund Information Repository. Each Superfund site has a local Superfund Information Repository nearby. Typically, these repositories are at a public library. The Repository contains the Community Relations Plan and other community outreach materials.



- **Local, State, or National Environmental or Citizen Groups.** Groups concerned with hazardous waste management or the cleanup of a specific site are an excellent source of information. For example, students can contact a local chapter of a national group, such as the Sierra Club, or a local activist group concerned with a specific site. Students should be able to find out about how other communities successfully influenced EPA's efforts at a site and get ideas for their own plans.

Class #2

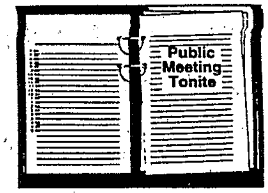
1. Have each group give its presentation and allow other students to ask questions. Ask group members what problems, if any, they encountered in preparing their presentations. Ask if they learned anything or met any people who were particularly surprising or interesting.

2. The discussion session should be interactive. Facilitate the discussion by asking both the presenter and the class questions. How do the suggestions from the groups representing the community residents differ from those of groups representing the CIC? Ask the class to explain the differing viewpoints and come up with ways to reach a common understanding.

   Some questions the class might consider include:

   - Are residents concerned that a major employer is responsible for site cleanup and that this liability may result in financial problems for the company or the community? If so, residents may oppose EPA's efforts to clean up the site and pressure EPA to permit the company to do the minimum, rather than undertake an expensive cleanup remedy.

   - Is the community concerned about the future use of the site? If so, the community may oppose site cleanup remedies that restrict future use and instead recommend solutions that will permit the community to either develop the property or create recreational facilities. Something like this happened at the Chisman Creek Superfund site in Virginia. Initially, the proposed site cleanup plan recommended that the site be fenced and use of the property be restricted. Local residents, however, had previously used the site for recreational purposes, such as motorbiking, walking, and fishing. Consequently, local residents objected to building a fence around the site. EPA worked with local government officials and the Potentially Responsible Party to convert the site into a county recreational facility with softball and soccer fields after cleanup. The facility now is equipped with field lighting, a parking lot, and restrooms.



- Do any non-English speaking people live in the community? If so, EPA needs to develop a community involvement strategy to reach out to this segment of the community as well.

- What else can EPA do to promote community involvement, particularly if the community does not seem interested?

- What are some innovative, creative, or unusual public participation activities EPA could do to increase community awareness and involvement? For instance, EPA could sponsor a radio talk show or local television cable show to answer questions about the site.

Conclude the class by describing a nearby site and asking if the site or the surrounding community has any unique characteristics that would require a specific type of outreach activity. For example, if the community is predominantly Hispanic, all of the site documents must be translated into Spanish. Or, if the site is located in an area where there is one primary employer, citizens may oppose EPA's presence at the site out of fear that the employer will be forced to go out of business and they will lose their jobs. In such a case, EPA efforts need to focus on relieving these anxieties.

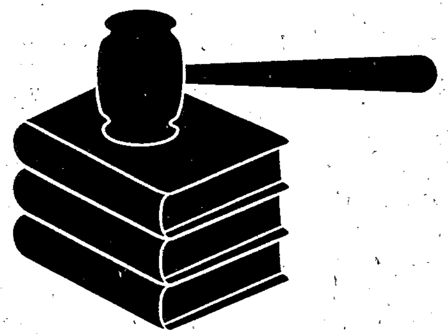
Extensions (Optional)

- Consider inviting an EPA or State Community Involvement Coordinator who is involved in overseeing public participation efforts at hazardous waste cleanup projects to attend the second class period, hear the presentations, and share with the class his or her own experiences (see the Contacts and Resources section at the end of the Haz-Ed materials for EPA and state contacts).

- Consider inviting to the second class period a community activist who lives near a hazardous waste site to describe his or her experiences related to the cleanup of the site.

Activity 12

Federal and State Laws on Hazardous Waste



Duration	1 class period
Grade Level	7-12
Key Terms/ Concepts	Hazardous waste Liability Potentially Responsible Parties Risk Superfund
Suggested Subjects	Civics/Government Social Studies

Purpose

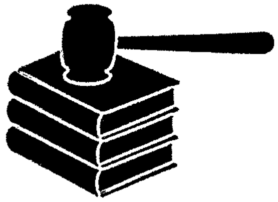
Students become familiar with how legislation on hazardous waste is developed, enacted, implemented, and enforced. Students gain an understanding of how hazardous waste cleanup laws are enacted and intended to function by creating a statute and set of regulations that parallel the issues covered by Superfund.

Background

Hazardous waste comes from a variety of sources, from both present and past activities. Years ago, before we understood the dangers of hazardous waste, there were no laws controlling its disposal. Many businesses simply threw out their hazardous waste with the rest of their trash—so it ended up in a landfill, was left behind when they moved, dumped in a river or lake, or buried in the ground.

Eventually, thousands of uncontrolled or abandoned hazardous waste sites were created in abandoned warehouses, manufacturing facilities, harbors, processing plants, and landfills, to name a few. Congress created the Superfund Program to investigate and clean up hazardous waste sites nationwide.

Fact Flash 2: The Superfund Cleanup Program, provides a good overview of what the U.S. Environmental Protection Agency (EPA) is trying to accomplish with the Superfund Program.



Under the law creating the Superfund Program, the people and companies responsible for the presence of the hazardous waste at a site are liable for its cleanup. EPA can make these responsible parties pay for or perform the study and cleanup work at the site. EPA negotiates with the **Potentially Responsible Parties (PRPs)** to reach an agreement. If the PRPs refuse to act, EPA pays for the cleanup with money from the Superfund trust fund and seeks to recover those costs from the responsible parties. If the PRPs cannot be identified or cannot pay for the cleanup, EPA can pay for the work out of the fund.

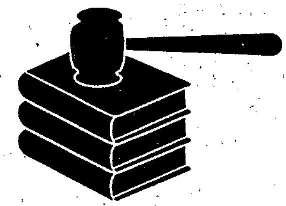
The law also creates severe **liability** for the PRPs EPA identifies at a particular site. This means that any individual PRP can be held responsible, or liable, for the cost or performance of the entire cleanup job, rather than just the portion that they caused. This kind of liability is unusual and gives EPA a powerful legal tool. The reason for it is best explained by the question "Who should pay?" The answer is that the polluter pays. Sites are usually abandoned, making the identification of all PRPs very difficult. Past recordkeeping at the site is frequently faulty, and often potential PRPs no longer exist or are bankrupt. Also, many sites are waste dumps often containing wastes from many different generators that have been mixed together; this makes equitable apportionment of liability impossible. The law says that those who profited from the businesses that created the harm should pay to clean it up instead of the public.

Finally, different contaminants pose different threats. Quantifying threats, as discussed in *Activity 6: Examining the Effects of Pollution on Ecosystems* and *Activity 7: Identifying Risks at a Superfund Site*, is complicated at best. For example, one PRP may have sent a small amount of a highly toxic waste to a site, while another may have sent a larger volume of a slightly toxic substance. Under Superfund, the government chooses not to try to apportion this liability among the PRPs.

To help prepare your students for this unit, use *Warm-Up Exercise 2: EPA's Superfund Program—Overview.*

As a follow-up to this unit, have your students perform *Activity 6: Examining the Effects of Pollution on Ecosystems; Activity 7: Identifying Risks at a Superfund Site;* and *Activity 11: What the Community Can Do.*

For more in-depth information on the topics covered in this unit, see *Fact Flash 10: Superfund Community Involvement Program* and *Fact Flash 11: Other Major Environmental Laws.* For additional information, see the Suggested Reading list found at the end of the Haz-Ed materials.



Preparation

1. Gather the following materials:

   - Copies for each student of the Student Handout, *Federal and State Laws on Hazardous Waste*
   - Copies for each student of *Fact Flash 2: The Superfund Cleanup Program.*

2. Read Fact Flash 2 to prepare your lecture.

3. Distribute the Student Handout and Fact Flash 2. Assign students to read Fact Flash 2 for homework and prepare responses to the questions in the Student Handout.

4. Explain that for the lesson on hazardous waste laws, students will be divided into groups. Each group will discuss the questions on the handout and devise a program for dealing with hazardous waste sites based on group consensus.

Procedure

1. Divide the class into groups. (The number of groups may vary, but each should include 5 or 6 students.)

2. Briefly review the concerns raised in the handout and the questions that students must answer when they are devising their program. If they were in charge, what would they do? What kind of laws would they need?

3. Have members of each group discuss among themselves how best to determine goals for dealing with hazardous waste sites and design a program to accomplish these goals. The group should also be prepared to discuss and advocate their program, and to answer questions posed by other students.

4. Remind the students that each member of the group should state his or her position on the issues, and the group should adopt a response to every question before moving on to the next one. If the group agrees on an issue, it should move on to the next one. If it cannot agree in a short time (e.g., 5 minutes), it should move on, considering the next question(s) in light of the alternative positions that were suggested for the problem question, until one response comes out as the best.

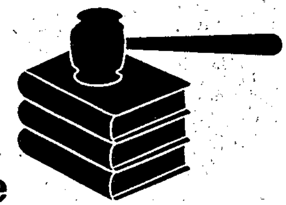
5. For the last 10 minutes of the period, tell the students to outline the program they have decided on. They should list the features of the program that respond to each question.

6. Collect the outlines and briefly review the features of each, noting where the groups agree and where the programs diverge.

Extensions (Optional)

- A second class period can be scheduled to compare and contrast the programs designed by the students with the actual Superfund Program. Each group can designate a spokesperson to respond to questions from the class and defend the approach taken by the group.

- Make copies and distribute *Fact Flash 11: Other Major Environmental Laws.* Discuss how the approach to environmental protection can differ according to program goals and the means available to achieve those goals.



Federal and State Laws on Hazardous Waste

Until 1980, there was no comprehensive Federal law that addressed the problems and threats posed by abandoned and inactive hazardous waste sites. Across the country there were thousands of abandoned and inactive hazardous waste sites that were exposing people to various health and safety risks. There were, however, a number of environmental laws that dealt with pollution, active hazardous waste facility management, and other environmental contamination.

In this exercise, your group will devise a program to deal with the problem of abandoned and inactive hazardous waste sites. By evaluating the following questions and developing responses, your group should be able to outline a program to address these sites. Remember, your program should include the underlying issues of identifying sites, assessing and ranking site hazards, reducing risk, identifying the people and companies responsible for the contamination, and financing the cleanup. While there are guidelines under each question to help you, feel free to discuss and adopt any approach that you feel responds to the question. These are the same basic questions addressed by Congressional and EPA policy makers when they developed the actual Superfund program.

1. **Should the government respond to threats posed by abandoned and inactive hazardous waste sites?**

   Consider the implications of taking action to reduce and eliminate the threats posed by abandoned and inactive hazardous waste sites versus doing nothing. If nothing is done, then thousands of these sites will continue to expose public health and the environment to possible harm. If the government decides to act, however, it will be taking on an enormous task: hazardous waste sites are common to every area of the country, and hazardous waste is not easily cleaned up. The job is usually very expensive.

2. **Should the government clean up such sites by removing or treating hazardous waste, or take other measures such as isolating or containing the waste?**

   Hazardous waste can be treated or disposed of in a way that reduces or eliminates risks to health and the environment. Most treatments include a process or technology that may increase the costs of taking action, but will reduce the health and safety risks to acceptable levels. Disposal in a permitted facility reduces risks by eliminating the danger of the uncontrolled wastes spreading. If the hazards are left untreated at the site, they could be dealt with more cheaply by somehow containing and isolating the site. This could be done with a fence or by posting warning signs. Remember that contaminants in soil will usually filter down and contaminate groundwater.

3. **Should the government clean up all contaminated sites or a limited number?**

Tens of thousands of sites around the country contain at least 1 substance that negatively impacts human health or the environment. These could all be defined as hazardous waste sites. If the government attempts to identify and respond to all of these sites, there would be no end in sight, since "new" sites are created as old ones are being cleaned. If only a limited number are addressed, however, this leaves the government open to problems related to selecting some sites but not others.

4. **If only a limited number of sites are cleaned up, how should the government select sites for cleanup? What factors will affect site selection?**

Selecting sites as targets for cleanup can be based on a number of factors. Think about the factors that could affect this decision and list them. Then select the ones that make the most sense. For example, should site selection focus on protecting human health, the environment, or both? Should sites be selected based on the ease with which they can be cleaned up, allowing the program to demonstrate success early on? Should selected sites be restricted to those close to large populations of people, or will attention to these only cause undue alarm in the nearby communities? Should site selection focus on scientific assessment of the sites, selecting sites that possess the most significant concentrations of hazardous waste? Should site cleanups be evenly distributed around the country, so that no one region feels left out? What if a site is highly contaminated but is far away from any populated areas?

5. **If a site is selected for cleanup, how should the methods to be used to perform the cleanup be selected? What factors should be considered in selecting the cleanup methods? What degree of cleanup should be achieved? Should it be the same for all sites?**

As mentioned above, there are many ways to approach a cleanup. If waste is simply removed, the site can be quickly cleaned, but the waste still exists: it just becomes someone else's problem. If a treatment technology is to be used, this could entail time delays, labor, and other costs. Selecting among alternative treatment technologies can be difficult, and can depend on the level of cleanup to be achieved. Should cleanup jobs remove all risks posed by a site? Could a cleanup job leave behind a reasonable amount of controlled waste? What if a particular contaminant is difficult or impossible to treat? Should cost be a factor in selecting the approach? What about acceptance of the approach by the local community?

6. Who should be liable (responsible) for the cleanup of a hazardous waste site?

This is a critical issue in your statute and should be carefully considered. Who should perform the cleanup? Who should pay? Should the Federal or state government perform or pay for all cleanups, since the society at large benefits from the production of goods that result in the generation of hazardous waste? Where would the money come from? Higher taxes? If the government performs the cleanup, should the states have to contribute? Should it be a public works program (performed by government employees) or should the government hire private companies to do cleanup work? Should individual parties responsible for the presence of the contaminated waste at the site be liable? If you hold the responsible parties liable, should they be allowed to assess the site and select the methods for cleanup? If more than one person is responsible for the site contamination, how should liability for site cleanup be allocated? What if one of those parties is the Federal government or a state or local government? What if some of the responsible parties no longer exist or are bankrupt?

7. How should the public be involved in your program?

Should they be informed of what is happening at the site when it happens? After it's done? Do they have a say in the decisions? Will the public's preferences be the most important factor? What kinds of programs will you set up to involve the public.

Activity 13

Creating the Future

Duration	2 1/4 class periods
Grade Level	7-12
Key Terms/ Concepts	Hazardous waste Superfund
Suggested Subjects	English Drama Journalism Life Science Social Studies Creative Writing

Purpose

This activity lets students create and write scenarios for the future related to hazardous waste pollution. The activity calls on students to describe their scenarios using one of a variety of formats—for example, a newspaper opinion/editorial article, a short story, a play, a poem.

Background

The United States and countries throughout the world are dealing with pollution problems from the past. Since Europeans came to this country, we have used natural resources as if they were inexhaustible. Early settlers cleared the forests to make way for towns and farms as they pushed from the east to the south and midwest and on to the west. The trees provided logs for building homes and heating them. The forests and rivers provided food. The skins of animals who lived in the forests provided materials for warm clothing. As more people came to North America, the use of natural resources increased.

Increases in population create more demand for goods and services. To meet these demands, industry needs more raw materials. Some of these materials, like cotton, rubber, and wood, are renewable, if managed correctly. Once they are harvested, a new crop can be planted. Some materials, however, like the fossil fuels used to produce energy, are not renewable. The Earth contains a fixed amount. The technology we developed made it possible for industry to use raw materials at a much greater rate than ever before, frequently faster than even the renewable resources could be replaced.

Technological progress and population growth have contributed to the production of **hazardous waste** that pollutes the land, air, and water. Hazardous waste comes from a wide variety of sources, and from both present and past activities. It most often is a by-product of manufacturing processes. Some of it comes from our homes as well, when we do not dispose of hazardous substances properly. The waste is hazardous because it contains chemicals that can have harmful effects on our health or the health of plants and animals (See *Fact Flash 1: Hazardous Substances and Hazardous Waste*).

Years ago, before we understood the dangers of hazardous waste, there were no laws controlling waste disposal. Eventually, thousands of uncontrolled or abandoned hazardous waste sites were created at manufacturing facilities, harbors, processing plants, landfills, and many other kinds of places. Congress created the Superfund Program to investigate and clean up hazardous waste sites nationwide.

Fact Flash 2: The Superfund Cleanup Program, provides a good overview of what EPA is trying to accomplish with the Superfund program.

To help prepare your students for this activity, use *Warm-Up 1: Defining Hazardous Waste* and *Warm-Up 5: Hazardous Waste Issues in the News.* You can perform the entire Warm-Up or simply review the main points covered in it. As a follow-up, have your students complete *Activity 5: How Hazardous Substances Affect People.*

Preparation

1. Gather the following materials:

   - Copies for each student of:
     Fact Flash 1: Hazardous Substances and Hazardous Waste
     Fact Flash 2: The Superfund Cleanup Program
   - Several copies (which students can share) of the Suggested Reading list at the end of the Haz-Ed materials.

Procedure

Class #1

1. List the following questions on the chalkboard:

   What if there were no Superfund Program?

   What would you do if there was no more landfill capacity?

   What if there was no control over hazardous waste?

   What if there was no hazardous waste?

2. Explain to students that they are to write a response to one of the questions on the chalkboard. Offer students the option to respond by writing a newspaper opinion/editorial article, a short story, a play, or a poem. Each should choose the format that best conveys his or her ideas.

3. Distribute *Fact Flash 1: Hazardous Substances and Hazardous Waste,* and *Fact Flash 2: The Superfund Cleanup Program.* Suggest that students also consult some of the books listed in the Suggested Reading list and other Fact Flashes in the Haz-Ed materials as background for this assignment.

4. Explain that students will be asked to share what they write with the class at a follow-up session (specify a date, but allow several days for research and preparation).

Class #2

1. Ask students to share what they wrote with the class. Have students compare and discuss the ideas presented. Are some students' ideas similar? If not, what are the differences? Did the materials they prepared suggest things we should be doing now to ensure a better future? Do some suggest more long-term things we should do—for example, 5 years or 10 years from now? Do students see a role for the government in shaping the future environment? Why or why not?

Extensions (Optional)

- Invite students from a different class to prepare materials based on these questions. Have them share their ideas in a school assembly as part of an Earth Day (spring) or Arbor Day (fall) commemoration or as part of another environmental observance.

- Have students send their essays, artwork, poems and so forth to a local newspaper and explore getting them published.

FACT FLASHES

FACT FLASH

1: Hazardous Substances and Hazardous Waste

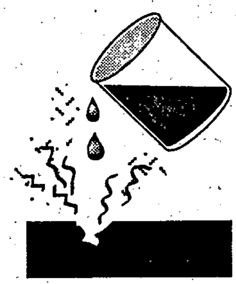
Chemicals affect our everyday lives. They are used to produce almost everything we use, from paper and plastics to medicines and food to gasoline, steel, and electronic equipment. More than 70,000 chemicals are used regularly around the world. Some occur naturally in the earth or atmosphere, others are synthetic, or human-made. When we use and dispose of them properly, they may enhance our quality of life. But when we use or dispose of them improperly, they can have harmful effects on humans, plants, and animals.

What is hazardous waste?

Even when used properly, many chemicals can still harm human health and the environment. When these **hazardous substances** are thrown away, they become **hazardous waste.** Hazardous waste is most often a by-product of a manufacturing process – material left after products are made. Some hazardous wastes come from our homes: our garbage can include such hazardous wastes as old batteries, bug spray cans, and paint thinner. Regardless of the source, unless we dispose of hazardous waste properly, it can create health risks for people and damage the environment.

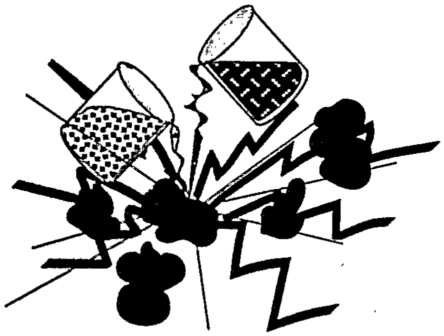
What kinds of hazardous waste are there?

Most hazardous waste is identified by one or more of its dangerous properties or characteristics: corrosive, ignitable, reactive, or toxic.

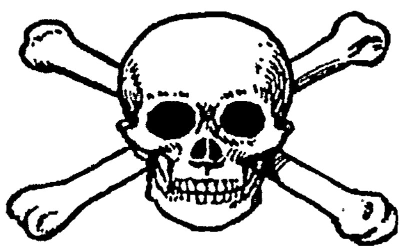


- **Corrosive** — A corrosive material can wear away (corrode) or destroy a substance. For example, most acids are corrosives that can eat through metal, burn skin on contact, and give off vapors that burn the eyes.

- **Ignitable** — An ignitable material can burst into flames easily. It poses a fire hazard; can irritate the skin, eyes, and lungs; and may give off harmful vapors. Gasoline, paint, and furniture polish are ignitable.



- **Reactive** — A reactive material can explode or create poisonous gas when combined with other chemicals. For example, chlorine bleach and ammonia are reactive and create a poisonous gas when they come into contact with each other.



- **Toxic** — Toxic materials or substances can poison people and other life. Toxic substances can cause illness and even death if swallowed or absorbed through the skin. Pesticides, weed killers, and many household cleaners are toxic.

Where does hazardous waste go?

Ideally, hazardous waste is reused or recycled. If this is not possible, hazardous waste is safely contained while it is stored, transported, and properly disposed of to prevent an accidental release into the environment. Advances in technology have greatly improved our ability to treat or dispose of hazardous waste in a way that prevents it from harming people or the environment. Typical methods of hazardous waste storage and disposal include **surface impoundments** (storing it in lined ponds), high temperature **incineration** (controlled burning), municipal and hazardous waste **landfills** (burying it in the ground), and **deep well injection** (pumping it into underground wells). More promising methods focus on minimizing waste, reusing and recycling chemicals, finding less hazardous alternatives, and using **innovative treatment technologies.**

What are the dangers of hazardous waste management?

Proper management and control can greatly reduce the dangers of hazardous waste. There are many rules for managing hazardous waste and preventing releases into the environment. Even so, a lot can go wrong when we try to contain hazardous waste. Even the most technologically advanced landfills we build will leak some day. Tanks used for storing petroleum products and other chemicals can leak and catch fire; underground storage tanks weaken over time and leak their hazardous contents. Transportation accidents, such as train crashes and overturned trucks, can occur while transporting hazardous substances. There are also cases of intentional and illegal dumping of hazardous waste in sewer systems, abandoned warehouses, or ditches in remote areas to avoid the costs and rules of safe disposal.

How can hazardous waste affect us?

When hazardous wastes are released in the air, water, or on the land they can spread, contaminating even more of the environment and posing greater threats to our health. For example, when rain falls on soil at a waste site, it can carry hazardous waste deeper into the ground and the underlying groundwater.

If a very small amount of a hazardous substance is released, it may become diluted to the point where it will not cause injury. A hazardous substance can cause injury or death to a person, plant, or animal if:

- A large amount is released at one time
- A small amount is released many times at the same place
- The substance does not become diluted
- The substance is very toxic (for example, arsenic).

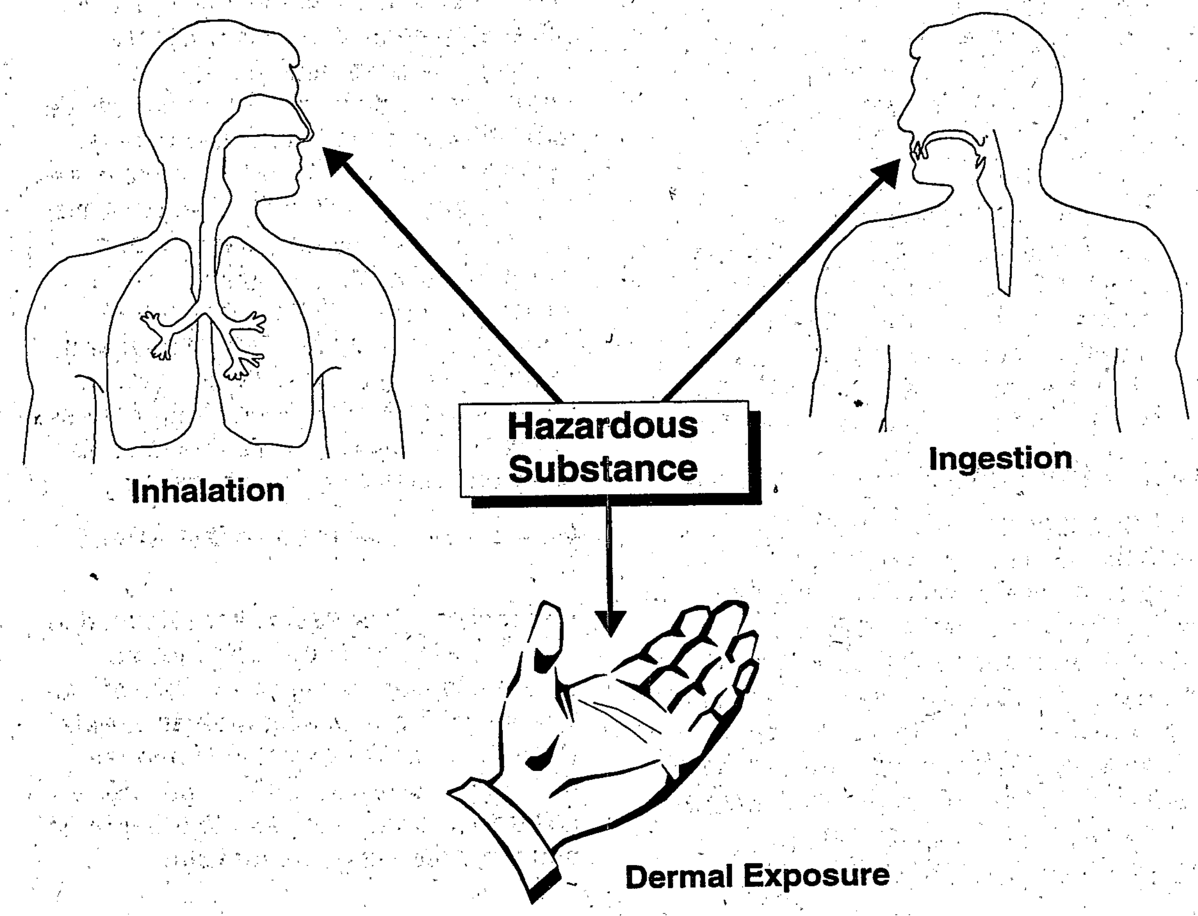
Coming into contact with a substance is called an **exposure**. The effects of exposure depend on:

- How the substance is used and disposed of
- Who is exposed to it
- The concentration, or **dose**, of exposure
- How someone is exposed
- How long or how often someone is exposed.

Humans, plants, and animals can be exposed to hazardous substances through inhalation, ingestion, or dermal exposure.

- *Inhalation* — we can breathe vapors from hazardous liquids or even from contaminated water while taking a shower.

Exposure Pathways

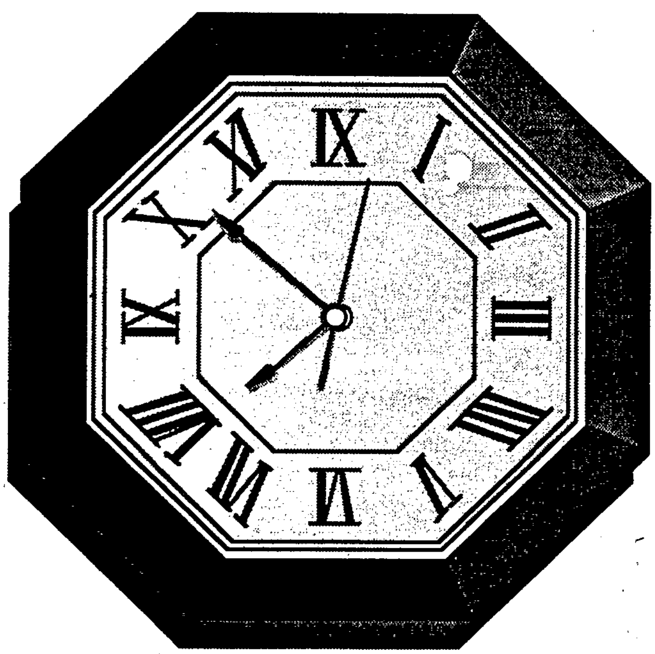


- *Ingestion* — we can eat fish, fruits and vegetables, or meat that has been contaminated through exposure to hazardous substances. Also, small children often eat soil or household materials that may be contaminated, such as paint chips containing lead. Probably the most common type of exposure is drinking contaminated water.
- *Dermal exposure* — a substance can come into direct contact with and be absorbed by our skin.

Exposures can be either acute or chronic. An **acute exposure** is a single exposure to a hazardous substance for a short time. Health symptoms may appear immediately after exposure; for example, the death of a fly when covered with bug spray or a burn on your arm when exposed to a strong acid such as from a leaking battery.

Chronic exposure occurs over a much longer period of time, usually with repeated exposures in smaller amounts. For example, people who lived near Love Canal, a leaking hazardous waste dump, did not notice the health effects of their chronic exposure for several years. Chronic health effects are typically illnesses or injuries that take a long time to develop, such as cancer, liver failure, or slowed growth and development.

One reason chronic exposure to even tiny amounts of hazardous substances can lead to harm is **bioaccumulation.** Some substances are absorbed and stay in our bodies rather than being excreted. They accumulate and cause harm over time.



FACT FLASH

2: The Superfund Cleanup Program

Years ago, before there were laws to control how hazardous chemicals were handled, many people disposed of hazardous waste by dumping it on the ground and in rivers or lakes, or burying it in the ground. The result? Eventually, thousands of hazardous waste sites were created at warehouses, harbors, manufacturing facilities, landfills, and many other kinds of places. In 1980 we began to get a handle on the problem, with the creation of the U.S. Environmental Protection Agency's (EPA) Superfund Program.

What is Superfund?

The U.S. Congress passed the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) in response to growing concern about health and environmental threats from hazardous waste sites. This law is commonly called Superfund. Working with states and Indian Tribal governments, Superfund requires EPA to deal with abandoned, accidentally spilled, or illegally dumped hazardous substances from the past, primarily from businesses and industry. Other types of pollution are handled by other environmental laws.

EPA can take three types of actions (known as **response actions**) to deal with abandoned hazardous waste sites: emergency responses, early actions, and long-term actions.

- An **emergency response** is used at a site that requires immediate action to eliminate serious risks to human health and the environment (for example, cleaning up chemicals spilled from an overturned truck on the highway).

- An **early action** is used at a site posing a threat in the near future by preventing human contact with contaminants such as providing clean drinking water to a neighborhood, removing hazardous materials from the site, or preventing contaminants from spreading. Early actions may last a few days or up to five years.

- A **long-term action** is used at a site where cleanup may take many years or decades (groundwater cleanups are frequently in this category). Often both early and long-term actions are performed at the same time. For example, leaking storage drums may be removed in an early action while contaminated soil is cleaned up under a long-term action.

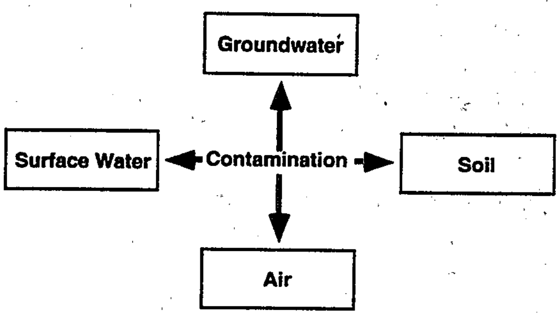
How does Superfund work?

EPA and state agencies find out about sites many ways – a phone call from a citizen, a reported accident, or a planned search to discover sites. EPA first reviews a site to decide what needs to be done. EPA collects information, inspects the area, and talks to people in the community to find out how the site affects them and the environment. Some sites don't require any action; others may be cleaned up by state agencies or other programs. The remaining sites – those that meet certain requirements – call for action by the Federal government.

At sites that require Federal action, EPA conducts tests to find out what hazardous substances are present and how serious the risks may be to people and the environment. To figure out how dangerous a hazardous waste site is, EPA uses a "scorecard" called the **Hazard Ranking System (HRS).** EPA uses the information it collected to score a site according to the risk it poses to people's health and the environment. **Risk** is a way of saying how likely it is that someone will be exposed to a hazardous substance, and the chance he or she will be harmed by that exposure. Environmental risk estimates how likely it is that a hazardous substance will harm the environment (water, plants, animals, air, and so forth).

To give an HRS score to a site, EPA looks at **migration pathways** – how contamination moves in the environment. EPA examines four migration pathways:

- **Groundwater** that may be used for drinking water
- **Surface water** (like rivers and lakes) used for drinking water, as well as for plant and animal habitats
- **Soil** that people may come in contact with or that can be absorbed lower in the food chain
- **Air** that carries contaminants.



Sites that get a high score on the HRS can be put on the **National Priorities List (NPL).** The NPL is a list of the nation's worst hazardous waste sites that qualify for extensive, long-term cleanup action under Superfund.

Once a site is placed on the NPL, a more detailed study further pinpoints the cause and extent of contamination, as well as the risks posed to people and the environment nearby. This information helps identify different ways to clean up the site. EPA lists these cleanup options in a proposed plan for long-term cleanup. The proposed plan describes different ways to clean up the site and the choice EPA prefers. The public has at least 30 days to comment on the plan.

After EPA answers the public's concerns, it publishes a **Record of Decision (ROD)** that describes how it will clean up the site. The cleanup method is designed to address the unique conditions at the site. The design and actual cleanup is conducted either by EPA, a state, or the people responsible for contaminating the site.

Who pays for the cleanup?

The law says EPA can make the people responsible for contamination pay for site studies and cleanup work. EPA negotiates with these **Potentially Responsible Parties (PRPs)** to reach an agreement. Sometimes EPA pays for the cleanup out of a pool of money called the Superfund and then tries to make PRPs pay back the costs. Superfund money comes mainly from taxes on chemical and petroleum industries.

Who's involved in the cleanup?

Like any team, EPA works with many other groups to clean up a Superfund site:

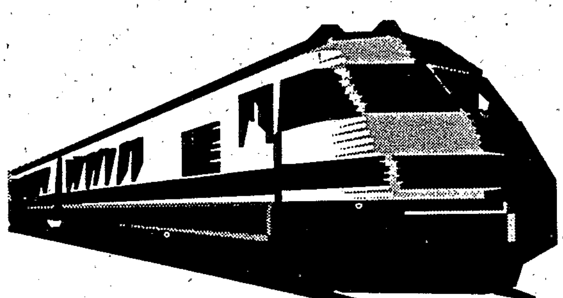
- **Communities** provide important information about the site and surrounding area. They ensure that citizens' concerns are addressed during the cleanup process. They also help determine what cleanup method should be used and how the site will be used in the future.
- **States** work with EPA on making cleanup decisions, pay for 10 percent of cleanup costs in their state, and make sure sites are maintained after cleanup. They may also lead the cleanup activities. In addition, states address other sites on their own.
- **PRPs** are responsible for and are encouraged to participate in all aspects of the cleanup. If PRPs refuse or are unable to pay for a cleanup, EPA may either legally require them to perform certain cleanup tasks or conduct the cleanup itself and try to make the PRPs pay EPA back.
- **Federal agencies** can be involved in site cleanup either as site owners, as PRPs, or as EPA's partners in conducting the cleanup (the Department of Justice, for example, provides legal help).
- **Contractors** can be hired by the PRP or EPA, and usually perform much of the actual cleanup work at a Superfund site.

FACT FLASH

3: Flowing Railroad Hazardous Waste Site

Site History

The 25-acre site is an inactive train yard located in the town of Ruralville (Map 1 and Map 2). The **Flowing Railroad** site was used for train engine maintenance and repair until it was abandoned in 1986. From 1976 to 1986, the yard was owned and operated by the **Flowing Railroad Company**, a division of FRR Enterprises. Although the Flowing Railroad Company is now bankrupt, **FRR Enterprises** is still operating. FRR Enterprises owns the site property, as well as **Flow Automations, Inc.**, a research and development plant that employs 200 Ruralville residents.



Various fuels, cleaning agents, detergents, and degreasers, including a hazardous solvent containing trichloroethylene (TCE), were used at the site for train maintenance. Solvents were stored outside in barrels. Some of the barrels rusted and leaked solvents onto the soil. Some solvents spilled onto the soil when barrels were filled, while more solvents were washed off the building floor and outside onto the soil. Flowing Railroad also had a solvent recycling plant. Sludge leftover from the recycling process was dumped in an open pit near the building (Map 3).

Before 1976, other industries at the site caused additional environmental contamination. The **Railroad Tie Treatment Company** occupied a portion of the site until 1950. The company treated railroad ties (the timbers laid across a railroad bed to support the tracks) with a liquid made from zinc chloride, a hazardous substance, to resist decay. The plant was closed in 1950 and the main treatment building was demolished. Building debris containing asbestos was left in a shallow ditch on the site. **Jimmy's Battery Salvage**, which reclaimed lead from car batteries, and **Recycling Services, Inc.**, a recycler of metals and electrical transformers, operated on the site from 1952 to 1972. Toxic chemicals (polychlorinated biphenyls, or PCBs) from the transformers were drained directly onto the ground.

Surrounding Area

Ruralville's town center, immediately west of the site, has both residential and business zones (Map 2). About 1,400 people live within a quarter of a mile of the site, while 8,000 people live within 1 mile of the site.

Utopia, the state capital with a population of 300,000, is 12 miles north of the site. Utopia's municipal water wells, which provide drinking water to homes and businesses in Ruralville and Utopia, are three miles south of the site and use groundwater.

The Flowing River, bordering the site to the east, flows from north to south and is popular for recreation and fishing. Three miles downstream of the site, an intake pipe supplies water from the river to irrigate 500 acres of farmland.

Site Discovery

Town officials investigated a fire on the train yard property. They noticed a peculiar odor from leaking, half-buried barrels and became concerned about the accessibility of the site to trespassers and other safety issues at the site. At the request of Ruralville's public works director, EPA began studying the site.

Health Concerns

EPA collected samples of soil and other materials at the site and tested them in a laboratory. The contaminants identified by EPA samples included:

- Lead, which can cause tumors and brain damage
- PCBs and TCE, which can cause cancer
- Zinc and copper, which can damage fish
- Asbestos, which can cause lung cancer if inhaled.

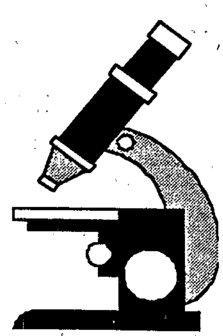
The risk of health problems related to these contaminants could rise if rain and melting snow pick up contaminants from contaminated areas and carry them to surface water (lakes, rivers, streams) and groundwater (fresh water underground). Health threats include breathing in fumes from the TCE. Trespassers at the site could be at particular risk, since they would have more contact with the chemical. Several families depend on fish from the Flowing River for meals three or four times a week. If contaminated, these fish could pose a relatively high risk to the health of these families.

Preliminary water samples from a well drilled at the site contained lead and high concentrations of TCE, although the full extent of contamination is unknown. No contamination was found in either a deep well or drinking water from the faucet. Drinking water may become contaminated in the future if the groundwater is contaminated. Soil contamination was found in a few areas, although a full test has not been conducted.

Community Concerns

The community is concerned about air contamination, water quality, economic impacts, and future land use.

- Two summers ago, some Ruralville residents complained to state authorities that strong wind gusts blew fine, white, snow-like particles over their homes. The state found that some topsoil at the site had eroded, exposing asbestos contamination. The state covered the area with soil. As long as the soil remains in place, it is unlikely that the asbestos will cause



an airborne health problem. Still, the community is concerned about potential air contamination. Other citizens are concerned about the health risks from TCE fumes.

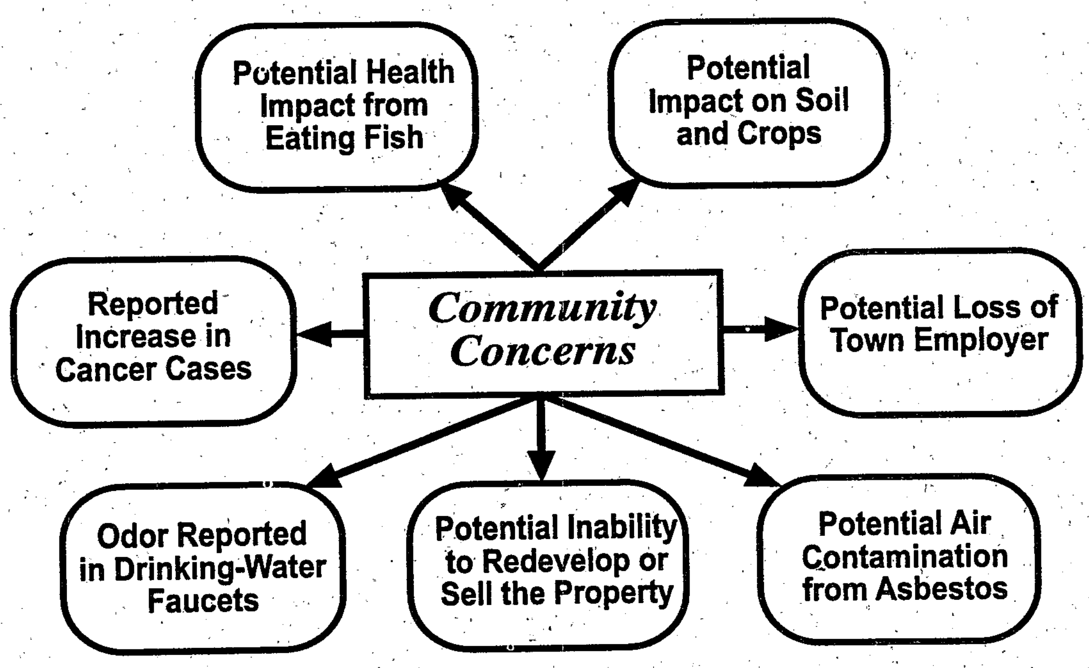
- Utopia and Ruralville citizens are concerned about the quality of the public well water. Some citizens blame contamination from the site for a recent increase in the number of cancer cases; others have reported that their tap water has a peculiar odor.

- Environmental activists are vocal about contamination of the Flowing River and the health risks to those who depend on fish from the river for their meals.

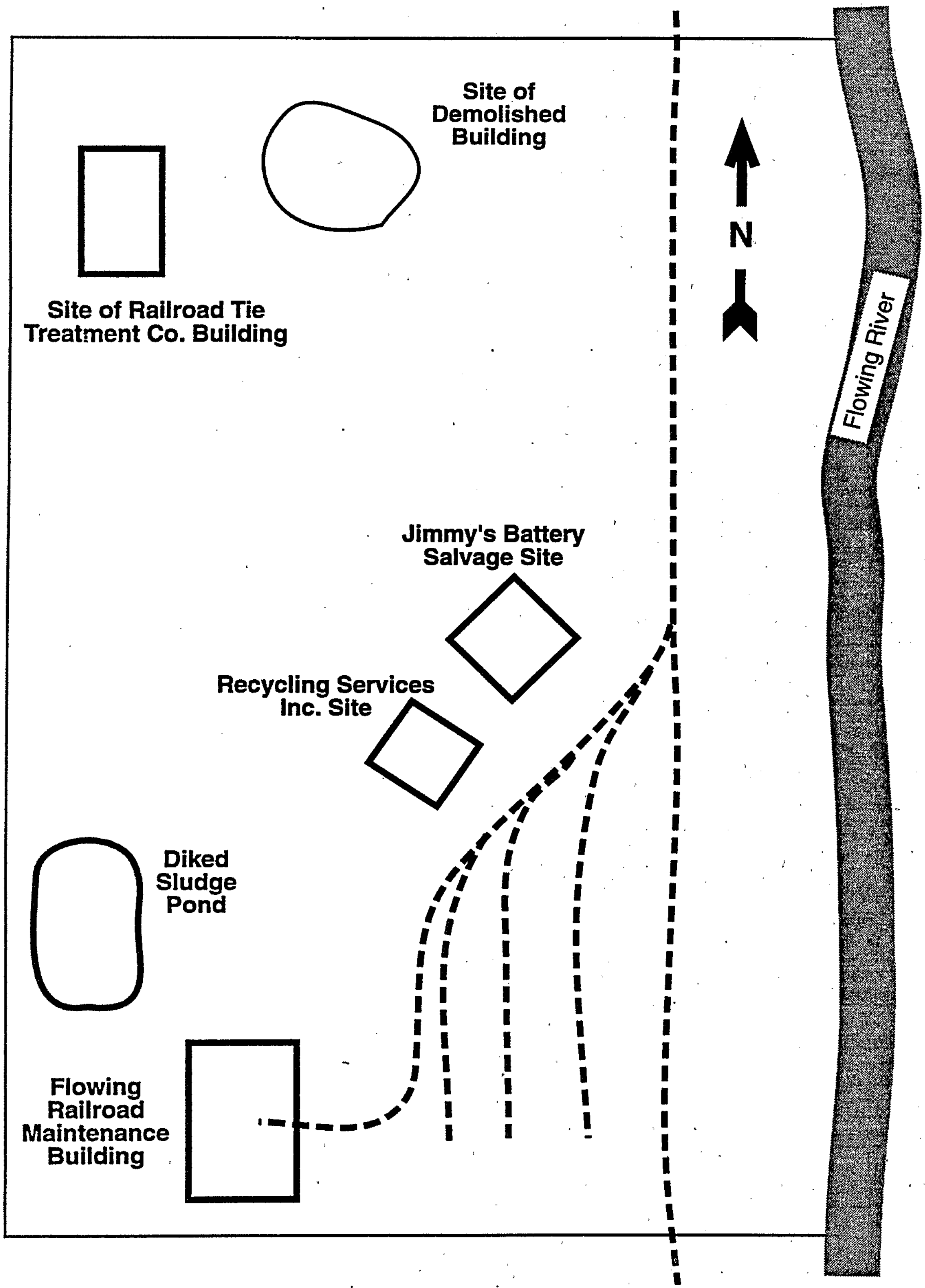
- FRR Enterprises has been a major source of money through tax revenue for Ruralville since 1976, as well as a major employer. Even after the train maintenance operation closed in 1986 the company continues to operate Flow Automations, Inc. The company is concerned about the amount of money it may have to pay for cleaning up the site. Although the company has expressed its commitment to working with EPA, the state, and the community, it has announced that if it has to pay a lot of money to clean up the site it may be forced to lay off workers or even close down Flow Automations.

- Also, farmers who use water from the Flowing River worry that contamination will damage their soil and crops, and reduce their income or cause them to lose their farms.

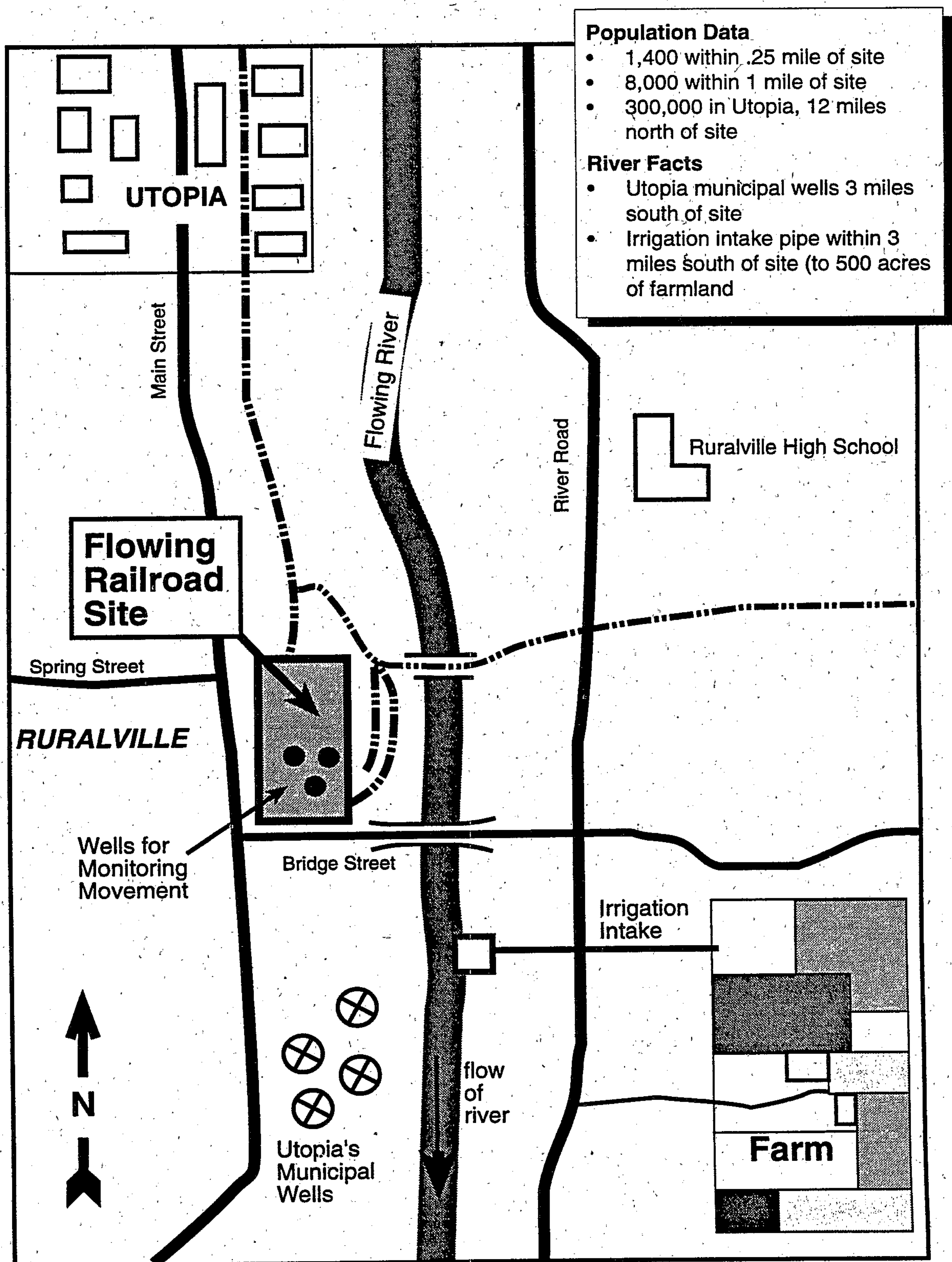
- Citizens are concerned about how the site will be used after it is cleaned up.



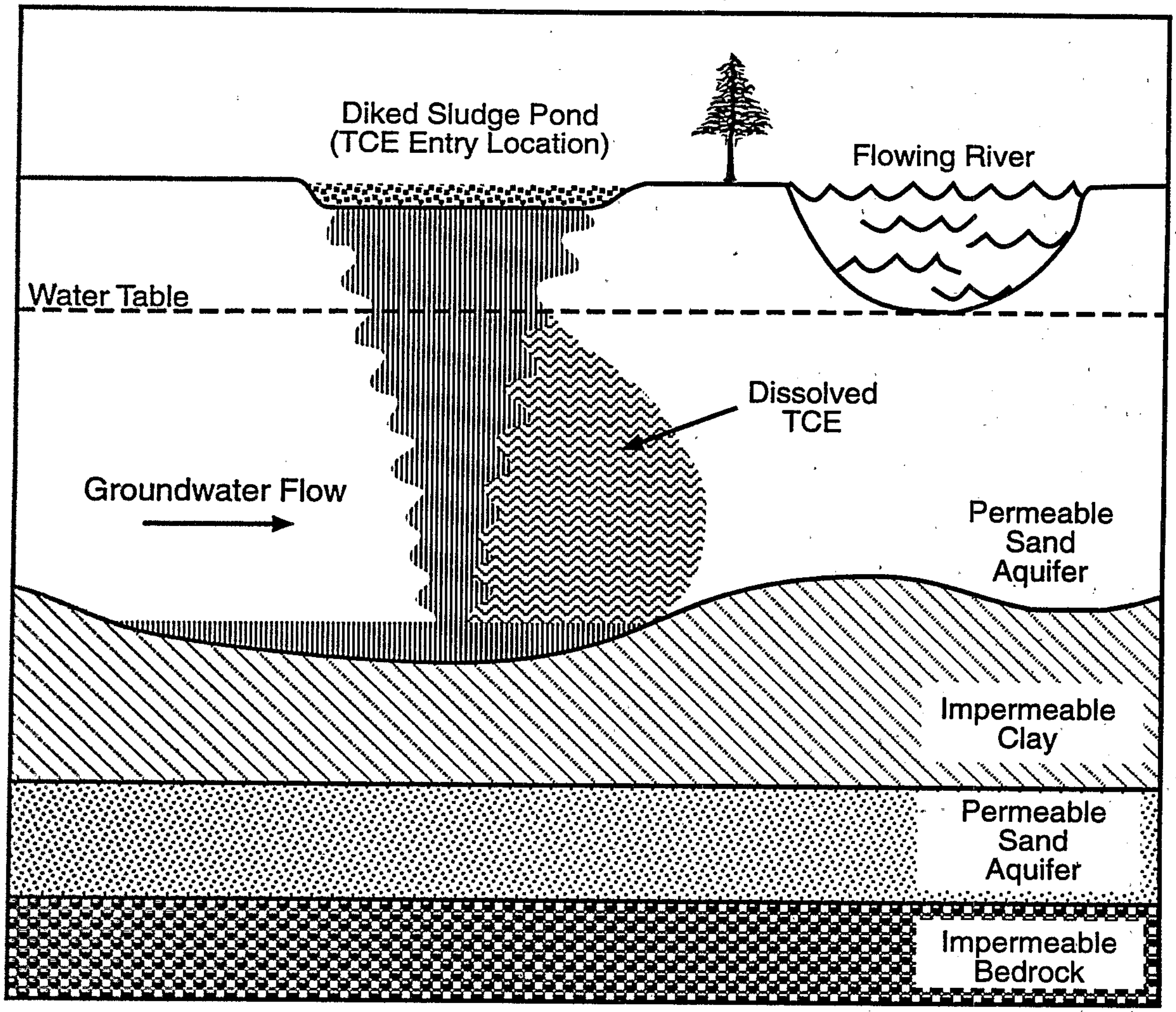
Map 1
Flowing Railroad Site



Map 2
Flowing Railroad Site Area



Map 3
Diked Sludge Pond, Cross-Section



FACT FLASH

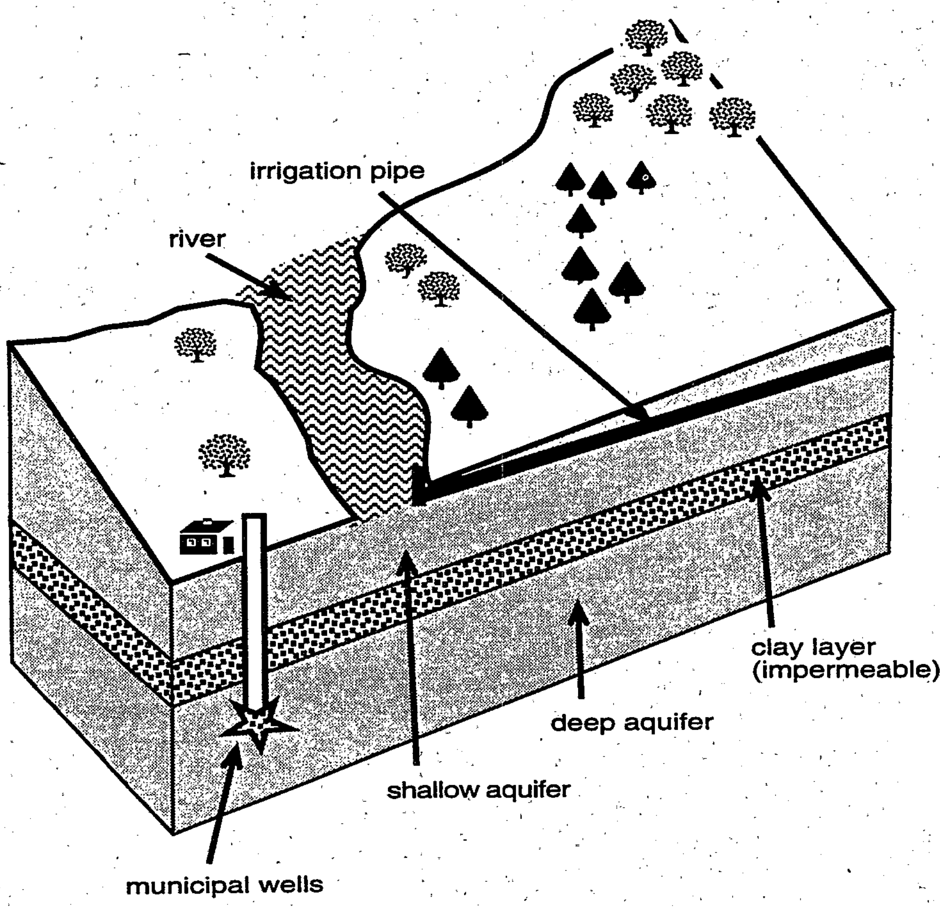
4: Flowing Railroad Site Investigation Results

EPA tested many samples taken from the site. Here are the results.

Groundwater

Nineteen groundwater monitoring wells were installed to analyze groundwater quality and movement. The studies show that:

- Two aquifers (underground rock formations storing groundwater) are in the immediate region, one shallow and one deep. The aquifers aren't connected.
- The shallow aquifer contains some hazardous substances from the site, including lead and high levels of TCE. Water in this aquifer is moving off-site, toward the Flowing River. No wells currently draw water from this aquifer, but the Flowing River is a major irrigation source for nearby farms.
- No contamination was found in the deep aquifer, which supplies water to the municipal wells.



Soil

Sixty soil samples taken from all around the site and from three nearby locations reveal:

- Only soil on the site itself is contaminated.
- High concentrations of TCE were found in the site's topsoil and in the soil up to 10 feet beneath the diked sludge pond.
- Copper, lead, and zinc were found in the soil by Jimmy's Battery Salvage site and the Railroad Tie Treatment Company building.
- PCBs were found in and just below the surface soil near the old Recycling Services, Inc., building.
- Asbestos was found in the surface soil near the demolished building.

Surface Water and Sediment

Ten surface water samples and six sediment samples (soil particles settled on the river bottom) from the Flowing River were analyzed to see if the site's hazardous contamination was affecting water quality or accumulating in the sediment. None of the samples showed any contamination.

Air

Air samples were collected from four locations to determine whether contamination from the site affects air quality nearby. Although no contaminants from the site were found in the air, strong winds could blow the topsoil away, releasing asbestos particles into the air.

FACT FLASH

5: Groundwater

What is groundwater?

Groundwater is fresh water (from rain or melting ice and snow) that soaks into the soil and is stored in the tiny spaces (pores) between rocks and particles of soil. Groundwater accounts for nearly 95 percent of the nation's fresh water resources. It can stay underground for hundreds of thousands of years, or it can come to the surface and help fill rivers, streams, lakes, ponds, and wetlands. Groundwater can also come to the surface as a spring or be pumped from a well. Both of these are common ways we get groundwater to drink. About 50 percent of our municipal, domestic, and agricultural water supply is groundwater.

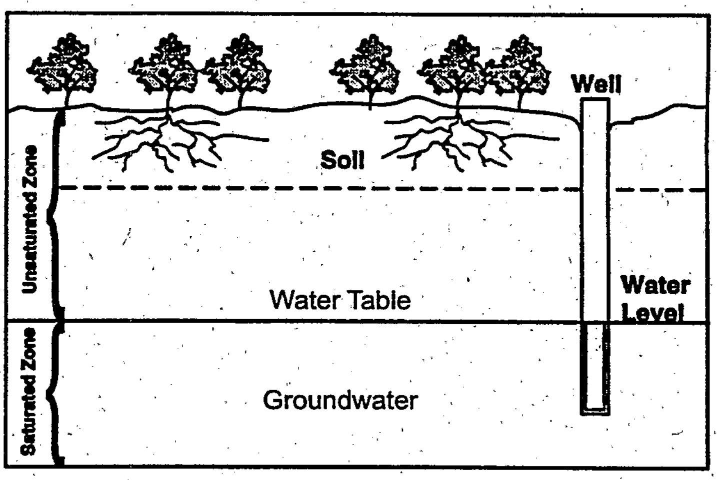
How does the ground store water?

Groundwater is stored in the tiny open spaces between rock and sand, soil, and gravel. How well loosely arranged rock (such as sand and gravel) holds water depends on the size of the rock particles. Layers of loosely arranged particles of uniform size (such as sand) tend to hold more water than layers of rock with materials of different sizes. This is because smaller rock materials settle in the spaces between larger rock materials, decreasing the amount of open space that can hold water.

Porosity (how well rock material holds water) is also affected by the shape of rock particles. Round particles will pack more tightly than particles with sharp edges. Material with angular-shaped edges has more open space and can hold more water.

Groundwater is found in two zones. The **unsaturated zone,** immediately below the land surface, contains water and air in the open spaces, or pores. The **saturated zone,** a zone in which all the pores and rock fractures are filled with water, underlies the unsaturated zone. The top of the saturated zone is called the **water table** (Diagram 1). The water table may be just below or hundreds of feet below the land surface.

Diagram 1
Groundwater Zones



What is an aquifer?

Where groundwater can move rapidly, such as through gravel and sandy deposits, an **aquifer** can form. In an aquifer, there is enough groundwater that it can be pumped to the surface and used for drinking water, irrigation, industry, or other uses.

For water to move through underground rock, pores or fractures in the rock must be connected. If rocks have good connections between pores or fractures and water can move freely through them, we say that the rock is **permeable.** **Permeability** refers to how well a material transmits water. If the pores or fractures are not connected, the rock material cannot produce water and is therefore not considered an aquifer. The amount of water an aquifer can hold depends on the volume of the underground rock materials and the size and number of pores and fractures that can fill with water.

An aquifer may be a few feet to several thousand feet thick, and less than a square mile or hundreds of thousands of square miles in area. For example, the High Plains Aquifer underlies about 280,000 square miles in 8 states—Colorado, Kansas, Nebraska, New Mexico, Oklahoma, South Dakota, Texas, and Wyoming.

How does water fill an aquifer?

Aquifers get water from precipitation (rain and snow) that filters through the unsaturated zone. Aquifers can also receive water from surface waters like lakes and rivers. When the aquifer is full, and the water table meets the surface of the ground, water stored in the aquifer can appear at the land surface as a spring or seep. **Recharge** areas are where aquifers take in water; **discharge** areas are where groundwater flows to the land surface. Water moves from higher-elevation areas of recharge to lower-elevation areas of discharge through the saturated zone.

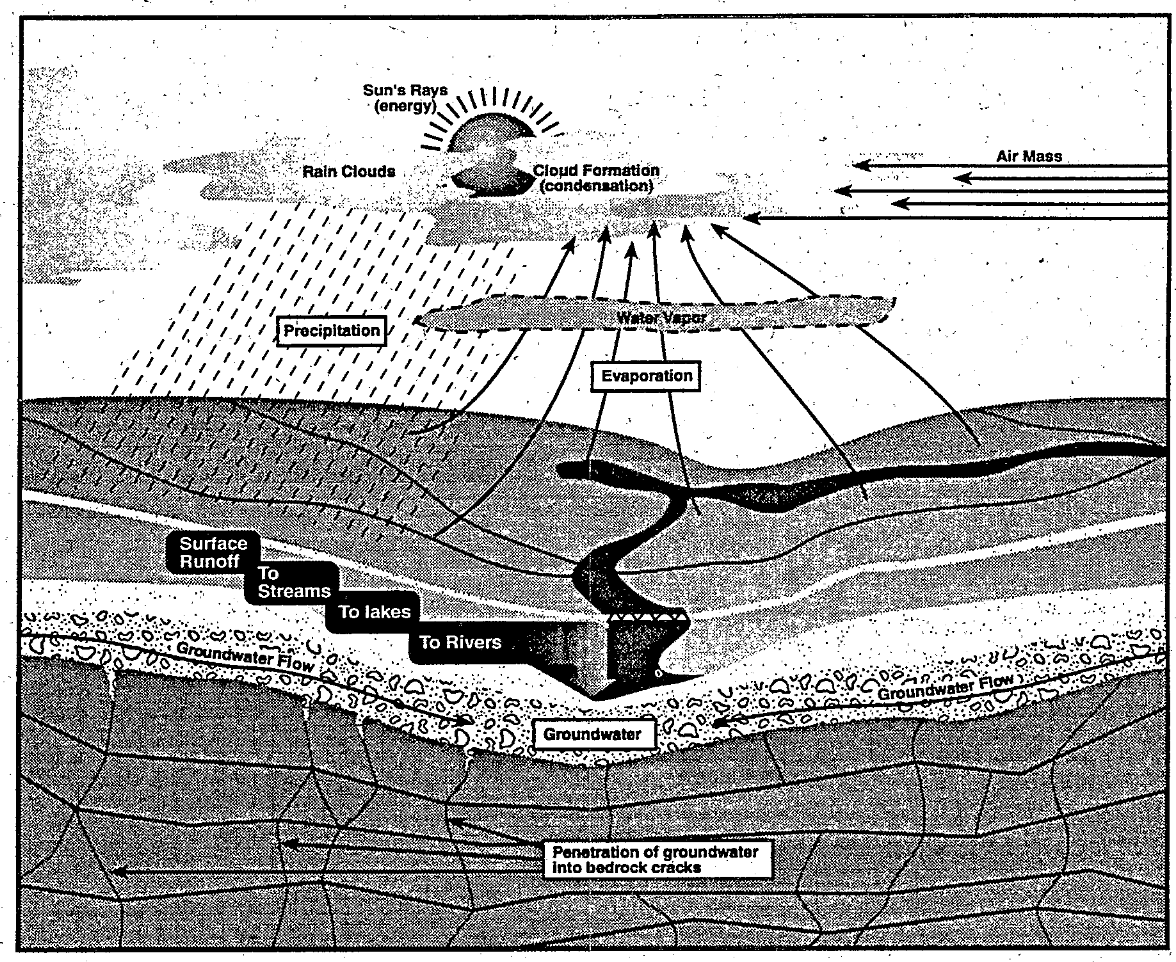
How does water circulate?

Surface water and groundwater are part of the **hydrologic cycle,** the constant movement of water above, on, and below the earth's surface (Diagram 2). The cycle has no beginning and no end, but you can understand it best by tracing it from precipitation.

Precipitation occurs in several forms, including rain, snow, and hail. Rain, for example, wets the ground surface. As more rain falls, water begins to filter into the ground. How fast water soaks into, or infiltrates the soil depends on soil type, land use, and the intensity and length of the storm. Water infiltrates faster into soils that are mostly sand than into those that are mostly clay or silt. Almost no water filters into paved areas. Rain that cannot be absorbed into the ground collects on the surface, forming **runoff** streams.

When the soil is completely saturated, additional water moves slowly down through the unsaturated zone to the saturated zone, replenishing or recharging the groundwater. Water then moves through the saturated zone to groundwater discharge areas.

Diagram 2
Hydrologic Cycle



Evaporation occurs when water from such surfaces as oceans, rivers, and ice is converted to vapor. Evaporation, together with **transpiration** from plants, rises above the Earth's surface, condenses, and forms clouds. Water from both runoff and from groundwater discharge moves toward streams and rivers and may eventually reach the ocean. Oceans are the largest surface water bodies that contribute to evaporation.

How is groundwater contaminated?

Groundwater can become contaminated in many ways. If surface water that recharges an aquifer is polluted, the groundwater will also become contaminated. Contaminated groundwater can then affect the quality of surface water at discharge areas. Groundwater can also become contaminated when liquid hazardous substances soak down through the soil into groundwater.

Contaminants that can dissolve in groundwater will move along with the water, potentially to wells used for drinking water. If there is a continuous source of contamination entering moving groundwater, an area of contaminated groundwater, called a **plume**, can form (Diagram 3). A combination of moving groundwater and a continuous source of contamination can, therefore, pollute very large volumes and areas of groundwater. Some plumes at Superfund sites are several miles long. More than 88 percent of current Superfund sites have some groundwater contamination.

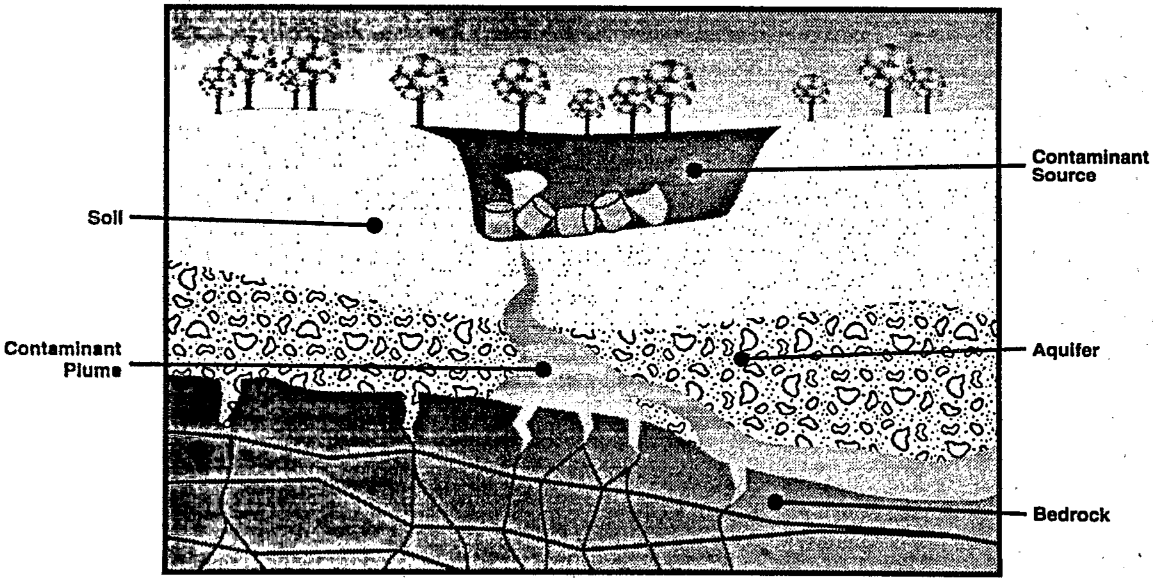
How do liquids contaminate groundwater?

Some hazardous substances dissolve very slowly in water. When these substances seep into groundwater faster than they can dissolve, some of the contaminants will stay in liquid form. If the liquid is less dense than water, it will float on top of the water table, like oil on water. Pollutants in this form are called **light non-aqueous phase liquids (LNAPLs)**. If the liquid is more dense than water, the pollutants are called **dense non-aqueous phase liquids (DNAPLs)**. DNAPLs sink to form pools at the bottom of an aquifer. These pools continue to contaminate the aquifer as they slowly dissolve and are carried away by moving groundwater. As DNAPLs flow downward through an aquifer, tiny globs of liquid become trapped in the spaces between soil particles. This form of groundwater contamination is called **residual contamination.**

What affects groundwater contamination?

Many processes can affect how contamination spreads and what happens to it in the groundwater, potentially making the contaminant more or less harmful, or toxic. Some of the most important processes affecting hazardous substances in groundwater are advection, sorption, and biological degradation.

Diagram 3
Contaminated Groundwater



- **Advection** occurs when contaminants move with the groundwater. This is the main form of contaminant migration in groundwater.

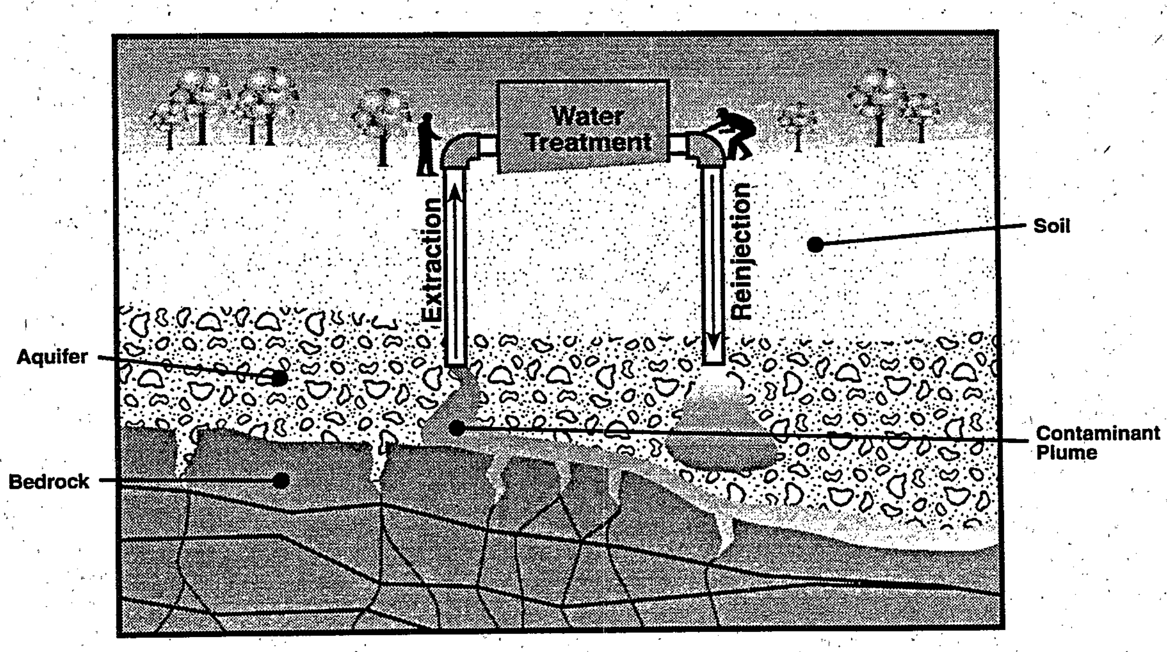
- **Sorption** occurs when contaminants attach themselves to soil particles. Sorption slows the movement of contaminants in groundwater, but also makes it harder to clean up contamination.

- **Biological degradation** happens when microorganisms, such as bacteria and fungi, use hazardous substances as a food and energy source. In the process, contaminants break down and hazardous substances often become less harmful.

Why is cleaning up groundwater so hard?

Cleaning up contaminated groundwater often takes longer than expected because groundwater systems are complicated and the contaminants are invisible to the naked eye. This makes it more difficult to find contaminants and to design a treatment system that either destroys the contaminants in the ground or takes them to the surface for cleanup. Groundwater contamination is the reason for most of Superfund's long-term cleanup actions. Diagram 4 illustrates groundwater treatment in action.

Diagram 4
Pumping and Treating Contaminated Groundwater



FACT FLASH

6: Resource Conservation and Recovery Act (RCRA)

Liquids, solids, sludges — wastes come in these forms and many more. Wastes may be materials left over from manufacturing, like bits of metal and plastic, dirty or used chemicals, or scraps. Waste can also be things we throw away in our homes, like newspapers, food, plastic wrappers, old cleaning fluids, and disposable razors. Whatever form waste takes, we have to manage and dispose of it properly to protect our health and the environment.

What is RCRA?

In 1976 Congress passed a law that requires careful disposal of household, municipal, and commercial and industrial waste: the **Resource Conservation and Recovery Act** (RCRA). Its goals are to:

- Conserve energy and natural resources
- Reduce the amount of waste generated
- Ensure that wastes are managed to protect human health and the environment.

RCRA gives EPA the power to make and enforce regulations for managing many kinds of waste. RCRA also allows states and Indian Tribes to have their own solid waste and hazardous waste programs in place of the Federal program, as long as their programs are at least as strong. If people and companies don't follow the regulations they can be fined or jailed.

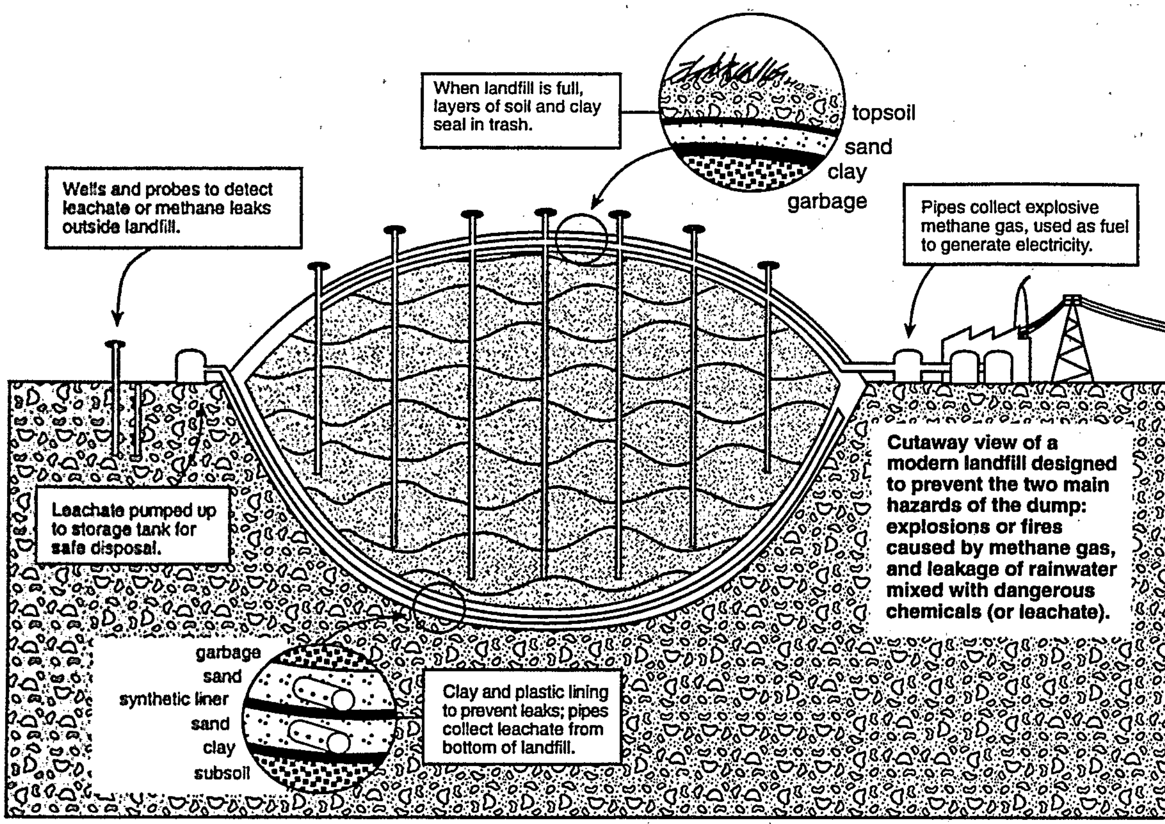
RCRA regulations apply to three basic kinds of waste management: municipal solid waste landfills; hazardous waste generators and treatment, storage, and disposal facilities; and underground tanks storing hazardous materials.

What is municipal solid waste?

Municipal solid waste (MSW) is mostly nonhazardous garbage from businesses and homes. Many communities face the problem of more and more garbage being thrown away, with less and less space to dispose of it. Did you know every year in the United States we dispose of...

1 billion foil-lined fruit juice boxes
2 billion used batteries
25 billion styrofoam cups
700,000 old TVs
1.6 billion disposable pens
700,000 junked cars
2 billion disposable razors
15 million tons of food
16 billion disposable diapers

Diagram 1
Example of a Properly Closed Landfill



By 2000, we are expected to produce over 220 million tons of garbage a year. Currently, there are about 36,000 municipal solid waste landfills in the United States. As we continue to produce more garbage, landfills are filling up and it is getting harder for communities to agree on where to put new landfills. While people may know that new landfills are needed, not many want them in their neighborhood. Landfills are also expensive to build.

How is MSW disposed of?

This garbage is usually disposed of in municipal solid waste landfills, placed in or on the land surface. If they are designed and operated right, landfills are lined to prevent leaks and have systems to collect leachate, potentially contaminated rainwater and other liquids that flow over the site and filter down through the landfill. Most landfills separate different types of waste in the landfill to prevent contact between incompatible wastes.

EPA regulations set minimum standards that municipal solid waste landfills must meet. These standards reduce the chance that landfills will cause pollution, specifying where landfills can be safely located, how they should be managed, and what must be done to clean up groundwater if it is contaminated. The regulations even require the landfill and surrounding areas to be monitored after it is filled up so that any problems can be found and fixed (Diagram 1). Landfills that don't meet these standards have to close or upgrade their operations to avoid legal action and penalties.

What is hazardous waste?

Hazardous waste is most often a by-product of a manufacturing process – material left after products are made. Some hazardous wastes come from our homes: our garbage can include such hazardous wastes as old batteries, bug spray cans, and paint thinner. About 250 million tons of hazardous waste are generated every year in this country. About 80 percent of this waste is disposed of on the land.

How does RCRA regulate hazardous waste?

EPA determines which wastes are hazardous. This is an ongoing process involving new research, tests, and health concerns. EPA's regulations make sure hazardous waste is managed safely from the moment it is generated until it is disposed. This "cradle to grave" approach has three key steps.

First, the person who creates the hazardous waste must keep track of it when it is moved from where it is produced. The tracking system requires the generator of the waste to package and label it properly for transportation. A manifest (list of cargo) travels with any transported hazardous waste, from the place it is produced to the place it is finally disposed of. This helps transporters and health and safety officials rapidly identify the waste and its hazards. About 12 million tons of hazardous waste are transported each year for treatment, storage, or disposal.

Second, hazardous waste management sites, such as hazardous waste landfills or incinerators, must meet many safety standards to get a permit to accept hazardous waste for treatment or disposal. For example, hazardous waste landfills are required to have liner systems to prevent leaks. Treatment facilities use different processes to recover material from the waste for reuse, to change the waste to make it less hazardous, or to reduce the volume of the waste.

Third, disposal of many hazardous wastes is not allowed unless the waste is treated to make it less hazardous.

Who is affected by RCRA?

Anyone who is involved in making or dealing with hazardous waste is affected by RCRA. The people who create, or generate hazardous waste, transport it, store it, treat it, and dispose of it all must follow many rules and requirements. Although most of the hazardous waste produced in the United States comes from a relatively small number of very large companies, companies that produce only small quantities of hazardous waste—such as auto repair shops, laboratories, printers, laundries, and drycleaners—are also regulated. Treating and disposing of hazardous waste is expensive and carries with it serious legal responsibilities.

What is an underground storage tank?

An underground storage tank is a large metal or fiberglass container designed to be buried in the ground and store liquid chemicals and other materials. The practice of burying tanks for underground storage was adopted to reduce the dangers of fire, explosion, weathering, and accident (such as hitting a tank with a car). There are about 1.5 million underground storage tanks (USTs) in the United States that contain hazardous substances or petroleum products (not counting farm and heating oil tanks). Of these, nearly 25 percent are leaking now or will leak in the future.

How does RCRA regulate USTs?

Unfortunately, there are problems with storing hazardous substances in the ground. Over time tanks rust, crack, and leak, and the equipment (pipes, pumps, and gauges) that connect tanks to the surface of the ground can fail as well. Groundwater can be contaminated by both accidental releases and the slow seepage of chemicals from buried storage tanks. To prevent leaks from tank corrosion, RCRA regulates how new tanks are built, including special rust protection. Tank owners must also show they can pay to clean up a leak if one occurs, and can compensate people who are injured or whose property is damaged because of the leak.

How does EPA enforce the RCRA regulations?

Individuals and companies that do not comply with RCRA regulations can face legal penalties. These penalties can be imposed by EPA or by a state. For minor violations, EPA or a state may simply tell a facility that it is not complying with the rules and that legal action will be taken if the owner does not comply within a certain period. For severe violations or in cases where the same violation has been repeated, a facility may face fines of up to $25,000 for every day past the deadline that it fails to comply. The facility's operations can also be suspended, or the operators can face criminal charges in court. Possible violations include falsifying information on a manifest, transporting waste without a manifest, or transporting waste to a facility that isn't operating legally.

How does RCRA encourage waste reduction?

RCRA has **source reduction** and **recycling** programs to reduce the amount of wastes discarded. Larger hazardous waste generators must certify that they have taken steps to reduce how much waste they produce. Often, waste reduction can help industry by cutting the costs of waste management. Recycling is also important in reducing waste. EPA has a national program to increase recycling of paper, glass, steel, plastics, and aluminum. At least 35 states have adopted some form of mandatory recycling.

How does RCRA encourage public participation?

RCRA provides on-going opportunities for public involvement in all facets of the program. RCRA allows citizens to take legal action against a person or company not complying with the regulations, or against EPA or a state for not properly enforcing the rules.

In addition, citizens are given the opportunity to voice their concerns about new rules and new facilities seeking a permit to operate in their community.

FACT FLASH

7: Pollution Prevention

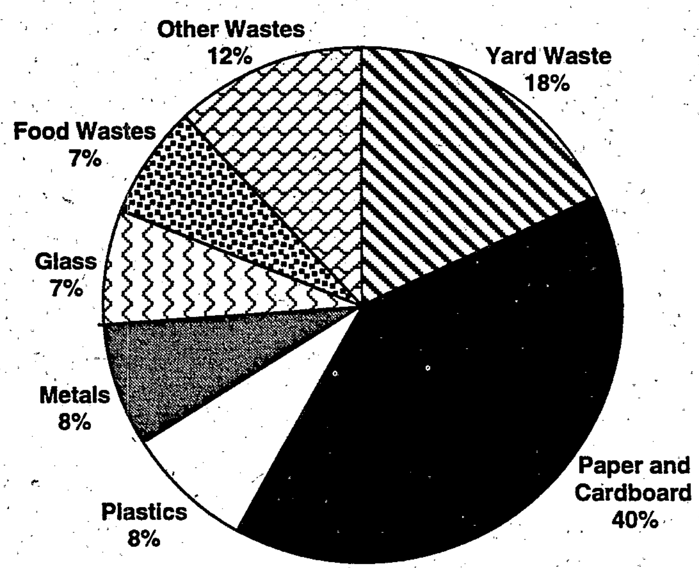
We can't make the problems caused by the waste we produce go away just by burying it in landfills. Reducing the problems our waste causes involves reducing how much waste we generate, and recycling the wastes we produce. Source reduction and recycling can reduce the amount of waste filling limited and expensive landfill space. EPA's recycling and source reduction efforts focus on wastes in three areas: municipal solid wastes, industrial hazardous wastes, and household wastes.

Municipal Solid Wastes

Municipal solid waste is generated in every place we live, work, or play — hospitals, houses, schools, businesses, football stadiums, and more. The garbage in municipal landfills consists of yard waste like grass clippings and tree branches, paper and cardboard, plastics, metals, glass, food, and other wastes. In 1990 Americans recycled or composted about 17 percent of the municipal waste they generated, and that figure is even higher today. But even though we recycled more, we also threw more away. That's why it is important to recycle, compost, reduce the amount of packaging used in the products we buy, and make products that last longer. Waste we avoid producing or that is reused is waste we don't have to dispose of yet. Important types of waste prevention include **composting**, **recycling**, **source reduction**, and **waste-to-energy incineration.**

- **Composting** yard waste allows materials such as grass clippings and fallen leaves to decompose naturally into valuable mulch (organic matter for gardening) instead of burying them in a landfill.
- **Recycling** collects and uses a waste product in making a new product. Recycled aluminum cans, for example, can be used to make new cans.

Municipal Waste Components



- **Source reduction** is cutting the amount of waste produced in the first place by reducing the amount of hazardous substances in products, eliminating wasteful packaging, and making products last longer. Source reduction requires manufacturers to make less wasteful products and consumers to actively purchase them.

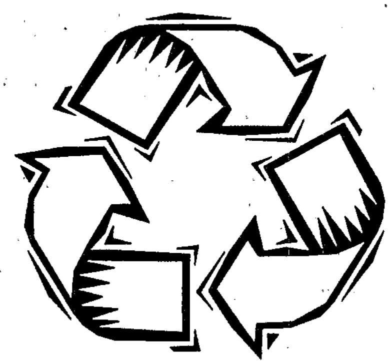
- **Waste-to-energy incineration** burns municipal waste to generate steam for electricity. Waste-to-energy plants can decrease waste volume by 60 to 90 percent, while recovering energy from discarded products.

Industrial Hazardous Waste

Why should industries reduce waste? The biggest incentive for industries to reduce the amount of waste they produce is that disposing of hazardous wastes is getting more and more expensive. When companies produce less waste, their disposal costs are lower. Companies may also profit from selling or saving recovered materials. Industries can reduce the amount of waste they produce in many ways: manufacturing process changes, source separation, recycling, raw material substitution, and product substitution.

- **Manufacturing process changes** involve either eliminating a process that produces a hazardous waste or changing the process so that it produces little or no hazardous waste. For example, many industrial operations involve applying paint. One way to reduce paint-related hazardous waste is to use low-toxicity paints, such as those that are water-based. Another way is to save excess paint and reuse it.

- **Source separation** refers to preventing hazardous waste from coming into contact with nonhazardous waste. It is the cheapest and easiest way to reduce hazardous waste. Source separation reduces costs for disposal, handling, and transportation and is widely used by industry. A good example is avoiding contamination of a large amount of water by using another method to clean hazardous materials from machines or products instead of washing them.



- **Recycling**, also referred to as recovery and reuse, is common in industry. Recycling removes a substance from a waste and returns it to productive use. Industries commonly recycle solvents, acids, and metals.

- **Substitution of raw materials** involves replacing raw materials that generate a large amount of hazardous waste with those that generate little or no waste. Manufacturers can substantially reduce waste volume through substitution. Industry often substitutes recycled products for raw natural resources. For example, a manufacturer can use recycled aluminum cans instead of aluminum ore in making new cans. Not only can recycled materials be cheaper than raw materials, but their use creates more demand for recycled products.

- **Product substitution** involves finding nonhazardous substitutes for materials and products used routinely in homes and businesses. For example, by using concrete posts instead of creosote-preserved wood posts in construction, builders can prevent hazardous creosote from leaching into the surrounding soil or groundwater.

Household Hazardous Waste

Some work around the home may require products that contain hazardous components. These commonly used products include certain paints, cleaners, stains and varnishes, car batteries, motor oil, and pesticides. When disposed of, these products become household hazardous waste.

Americans generate 1.6 million tons of household hazardous waste a year. Household hazardous waste is sometimes disposed of improperly when it is poured down the drain, onto the ground, or into storm sewers, or by being put in the trash. Some household hazardous waste can injure sanitation workers, contaminate wastewater treatment systems, or leak out of landfills into groundwater.

One way to reduce problems from household hazardous waste is to use nonhazardous or less hazardous compounds. People can do this by learning about alternative products that are available and choosing those that are less toxic. If you must use products with hazardous components, use only the amount you need. Leftover products can be shared with neighbors; donated to a business, charity, or government agency; or given to a household hazardous waste collection program.

Recycling is an economical and environmentally sound way to handle some types of household hazardous waste, such as used car batteries and motor oil. Auto parts stores and service stations often accept used car batteries and used oil for recycling.

Because household hazardous waste can be dangerous, you should always use, store, and dispose of materials containing hazardous waste safely. To prevent accidents, follow disposal instructions on the label and dispose of these products through a local collection program, if possible. More than 3,000 collection programs for household hazardous waste currently operate in the United States.

FACT FLASH

8: Common Cleanup Methods

Hazardous wastes are often treated to reduce their volume or toxicity and to protect human health and the environment. Other cleanup methods focus on safe management. This Fact Flash presents five common ways of treating hazardous waste: air stripping, capping, precipitation, excavation, and incineration.

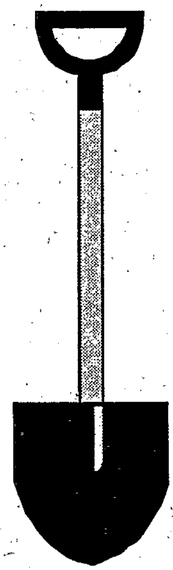
AIR STRIPPING

What is it?

Air stripping removes volatile organic compounds from contaminated groundwater or surface water. Volatile organic compounds, or VOCs, are chemicals that quickly vaporize when heated or disturbed. For example, the gasoline fumes you smell at the gas station are VOCs volatilized in the air. In air stripping, these vapors are transferred from the water in which they were dissolved into a passing air stream. This air stream can be further processed to collect and reuse or destroy the VOCs.

How does it work?

The process starts when contaminated surface water or groundwater is pumped from large storage tanks into the top of a "packed tower" attached to an air blower. This packed tower is simply a large metal cylinder packed with material. While the stream of contaminated water is released into the tower, an air stream is pumped up from the bottom. The material in the tower forces the water stream to trickle down through various channels and air spaces. As the air stream flows upward, the contact of the two streams, called the "counter-current" flow, vaporizes the VOCs out of the water stream and collects them in the air stream, which exits the top of the tower.



How does the tower's packing material work? Inside the packed tower, the water stream forms a thin film on the material, which allows much more of the air stream to come into contact with the water stream. Using smaller packing material increases the surface area available for air stripping and improves the transfer process.

Why is it used?

Air stripping is useful for removing VOCs like trichloroethylene (TCE), dichloroethylene, chlorobenzene, and vinyl chloride. These are all hazardous substances. Equipment used in air stripping is relatively simple, allowing for quick start-up and shutdown and easy maintenance. This makes air stripping well-suited for hazardous waste site operations.

An important factor to consider in using air stripping is its impact on air pollution. Moving VOCs from water to air can mean just transferring pollution. Gases generated during air stripping may need to be collected and treated before they can be released into the air to avoid damaging the atmosphere.

How well does it work?

Air stripping can remove up to 98 percent of VOCs and up to 80 percent of certain semivolatile compounds. It does not work well for removing metals or inorganic contaminants.

CAPPING

What is it?

Capping, often used in combination with other cleanup methods, covers buried wastes to prevent contaminants from spreading. Spreading, or migration, can be caused by rainwater or surface water moving through the site or by wind blowing dust off a site. Caps are usually made of a combination of materials like synthetic fibers, heavy clays, and sometimes concrete. Caps should minimize water movement through the wastes using efficient drainage; resist damage caused by settling; prevent standing water by funneling away as much water as the underlying filter or soils can handle; and allow easy maintenance.

How does it work?

The primary purpose of a cap is to minimize contact between rain or surface water and the buried waste. Two types of caps, multilayered and single-layer, serve this purpose.

- *Multilayered caps* have three layers: vegetation, drainage, and water-resistant. The vegetation layer prevents erosion of the cap's soils; the drainage layer channels rainwater away from the cap and keeps water from collecting on the water-resistant layer, which covers the waste.
- *Single-layer caps* are made of any material that resists water penetration. The most effective single-layer caps are made of concrete or asphalt, but single-layer caps are usually not acceptable unless there are valid reasons for not using a multilayer cap.

Why is it used?

Capping is required when contaminated materials are left in place at a site. It is used when the underground contamination is so extensive that excavating and removing it isn't practical, or when removing wastes would be more dangerous to human health and the environment than leaving them in place. Wells are often used to monitor groundwater where a cap has been installed to detect any movement of the wastes.

How well does it work?

Capping works well for sealing off contamination from the above-ground environment and reducing underground waste migration. Caps can be put over virtually any site, and can be completed relatively quickly. Capping materials and equipment are readily available. A multilayered cap will usually last for at least 20 years. Proper maintenance will make it last even longer.

PRECIPITATION

What is it?

Precipitation separates heavy metals from the water they contaminate.

How does it work?

Precipitation changes dissolved heavy metal contaminants into a solid form that can be separated from the water. Water contaminated with heavy metals is treated with chemicals, which cause the metal molecules to stick together and separate from the water. The solids are removed from the water. The clean water is then pumped back into the ground and the collected metals are properly disposed of (Diagram 1).

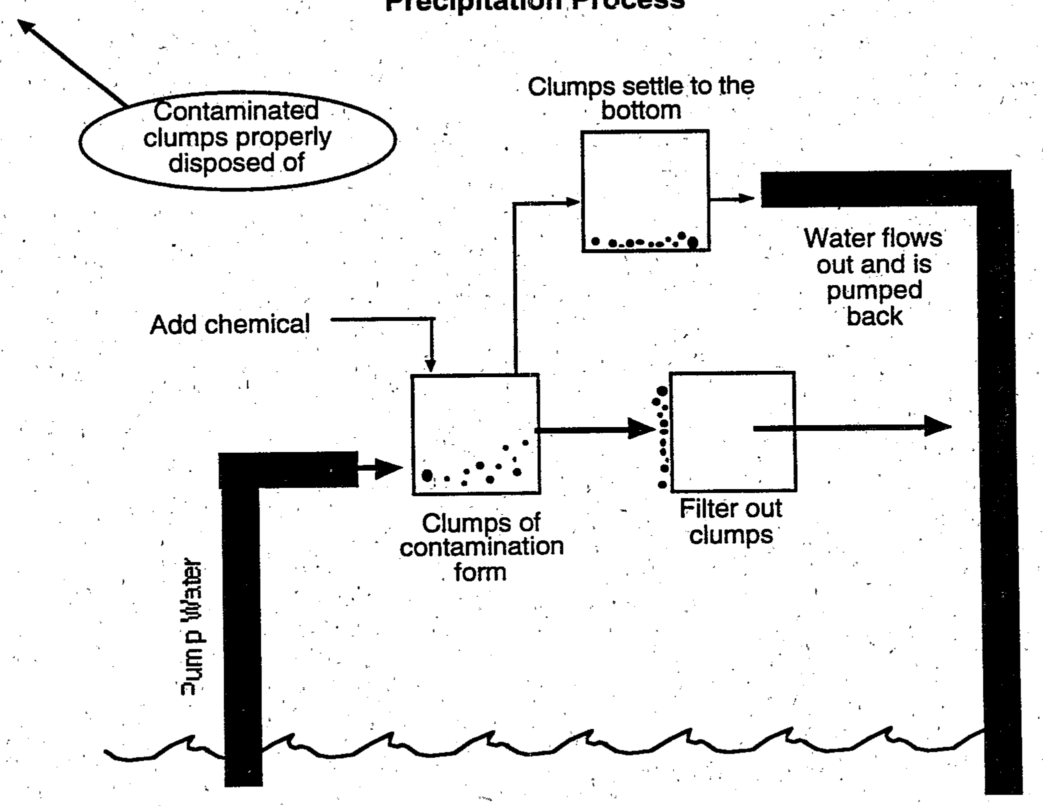
Why is it used?

Precipitation is easy to perform and can be used in many areas. It efficiently treats contaminated groundwater for reuse, and is one of the main methods of treating industrial wastewaters.

How well does it work?

Precipitation can be costly and is difficult to use if the water is contaminated with many types of metals, since different metals may interfere with one another and the cleanup process. Precipitation is very successful in treating wastewaters and is becoming the most widely selected cleanup method for removing heavy metals from groundwater.

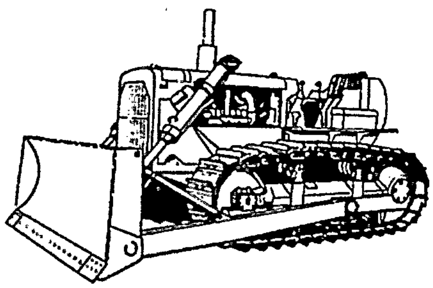
Diagram 1
Precipitation Process



EXCAVATION

What is it?

Excavation removes contaminated material from a hazardous waste site using heavy construction equipment, such as backhoes, bulldozers, and front loaders. At certain sites, specially designed equipment may be used to prevent the spread of contaminants.



How does it work?

The first step in excavation involves sampling and mapping the contaminated area to identify the contaminated area to be excavated. Samples are taken at several different depths in the same location so that a vertical, as well as horizontal, map of the contamination may be developed. Historical records, such as photographs or eye-witness accounts from past employees, and the contamination's effects on vegetation can also be used to pinpoint the area to be excavated.

Once the contamination is fully mapped, it can be removed. When hazardous waste has been buried in the ground a layer of soil may need to be removed before the waste is excavated. This layer, called overburden, is set aside and is later replaced in its original location. Contaminated materials are then dug up and loaded onto trucks for hauling. After it is cleaned up, excavated soil may be returned to its original location for use as backfill. Soil in the walls and bottom of the excavated area is tested to ensure that all contamination has been removed. Excavation proceeds until cleanup goals are met.

Excavation of hazardous waste or contaminated materials must be carefully planned to make sure contamination doesn't spread to clean areas of the site. For example, once excavation equipment is in a contaminated area, it must stay there until the work is completed, then thoroughly cleaned and decontaminated prior to leaving the site. In the event that contaminants have seeped into the groundwater, additional treatment may be necessary.

Why is it used?

Hazardous wastes can generally be excavated without exposing people near the site to contamination. Wastes can be removed for further treatment or disposal at an approved landfill. Excavation uses common construction equipment and is a widely used and accepted method of dealing with hazardous waste. Excavation is also relatively inexpensive compared to other, more complicated treatment technologies.

How well does it work?

Excavation is very effective in removing contamination and is commonly used at remediation sites. There are no strict limits on the types of wastes that can be excavated and removed. Concern for worker health and safety, however, may prevent excavation of explosive, reactive, or highly toxic waste material.

INCINERATION

What is it?

Incineration involves burning hazardous wastes to destroy such organic compounds as dioxins and PCBs. Incinerators can handle many forms of waste, including contaminated soils, sludges, solids, and liquids. Incineration is not effective in treating inorganic substances such as hydrochloric acid, salts, and metals.

EPA establishes and specifies the conditions under which each incinerator can operate by issuing permits. A permit defines how the incinerator must operate, such as:

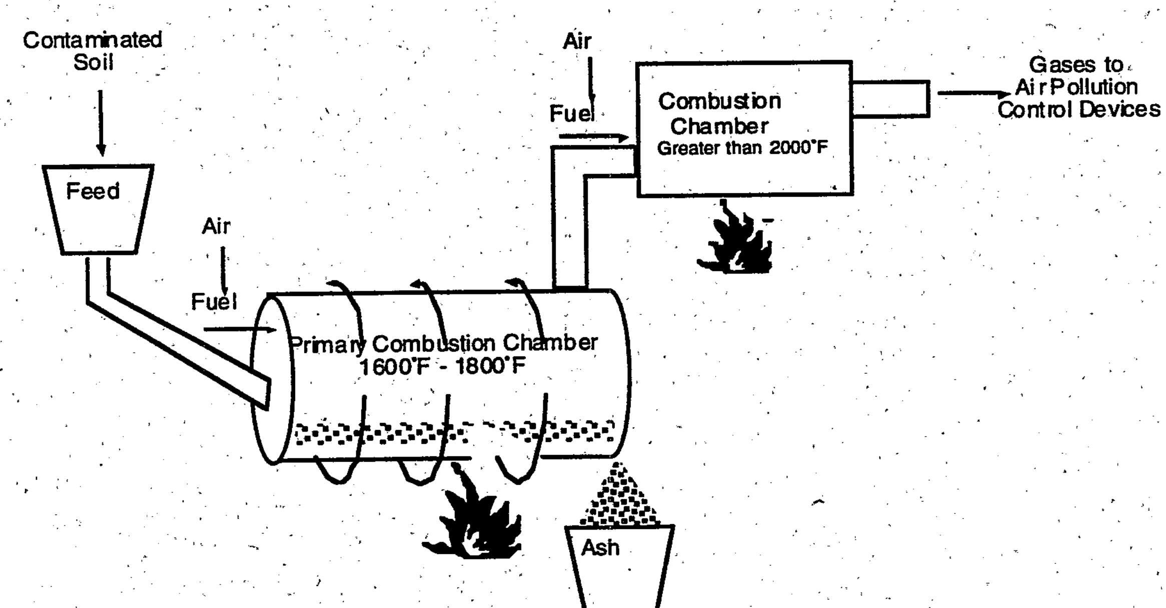
- Maximum carbon monoxide level in stack gases (gases from the combustion process which exit the stack after treatment by air pollution control devices)
- Maximum feed rates (how fast hazardous wastes are fed into the incinerator)
- Minimum burning temperature.

The permit conditions are designed to deliver a "complete burn" of the hazardous waste. For example, a permit requires the waste feed to be cut off if burning conditions are not optimal.

How does it work?

Incineration uses high temperatures (between 1600°F and 2500°F) to degrade contaminants into nontoxic substances, such as water, carbon dioxide, and nitrogen oxides (nitrogen and oxygen). Properly done, high-temperature incineration can be an effective, odorless, and smokeless process. The process is illustrated in Diagram 2.

Diagram 2
Incineration Process



EPA incinerator regulations assume that all leftover ash and material removed from the incinerator are hazardous. Accordingly, they must be disposed of at a facility that has a permit to handle hazardous waste. In addition, water used in the incineration process must meet strict standards before it can be discharged to surface waters.

Why is it used?

Incineration can be a permanent waste disposal solution because it destroys wastes that would otherwise take up space in a landfill. Incineration effectively destroy over 99 percent of all organic compounds.

A common misconception is that the more toxic the chemical, the more difficult it is to burn. EPA's research shows that how toxic a chemical is does not relate to how easily it breaks down under heat during incineration.

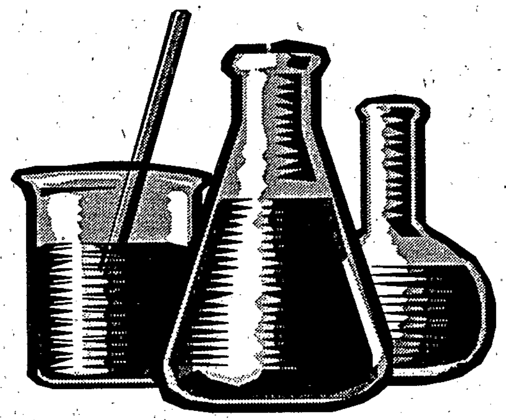
How well does it work?

No incinerator can destroy 100 percent of the hazardous waste fed into it. Small amounts are released into the atmosphere through the incinerator stack or are mixed with the ash. EPA requires that each incinerator destroy and remove 99.99 percent of all hazardous waste it processes. For PCBs and dioxin wastes, the standard is 99.999 percent. When operated properly, incinerators can meet or exceed these standards. Operating at this level of efficiency, however, is a complex, highly technical task.

FACT FLASH

9: Common Contaminants

While each Superfund site is unique, with different conditions, history, and contamination, some contaminants are commonly found at many sites. This Fact Flash describes these common contaminants, how people can be exposed to them, and how they can affect human health.



ASBESTOS

What is it?

Asbestos is the name used for any of six minerals (amosite, chrysotile, tremolite, actinolite, anthophyllite, and crocidolite) that occur naturally in the environment. The most common mineral type is white (chrysotile). These minerals are made up of long, thin fibers similar to fiberglass. Asbestos fibers are very strong and heat-resistant, leading to the use of asbestos in a wide range of products, mostly in building materials and heat-resistant fabrics. Asbestos fibers do not evaporate or dissolve in water, and are not broken down over time. They usually settle out of air and water and are deposited in soil or sediment, but very small fragments can remain in the air or in water.

How can exposure occur?

Inhaling tiny asbestos fibers suspended in air is the most likely **exposure route,** or the way in which people come into contact with a substance. Asbestos can be detected in almost any air sample. In rural areas there is usually an average of 0.03 to 3 fibers in a cubic meter of outdoor air (about the amount of air you breathe in one hour), while levels near an asbestos mine or factory can reach 2,000 fibers per cubic meter or higher. Levels also could be above average near a building that is being demolished or renovated, or near sites where asbestos wastes are not properly protected from being spread by the wind.

Inhaled asbestos fibers may be deposited in the passages and on the cells of the lungs. Most fibers are removed from the lungs by being carried away in a layer of mucus to the throat, where they are swallowed into the stomach. This usually takes place within a few hours, but fibers deposited in the deepest parts of the lung are removed more slowly. Some can remain for many years or may never be removed.

Asbestos exposure can also result from drinking fibers present in water. Fibers can enter water by being eroded from natural deposits, or from cement pipes used to carry drinking water. Most drinking water supplies in the United States have concentrations of less than one million fibers per liter.

Nearly all swallowed asbestos fibers pass along the intestines within a few days and are excreted. A small number of fibers remain in cells that line the stomach or intestines, and a few enter the blood. Some of these become trapped in other tissues, while others are removed in the urine.

How can it affect human health?

Exposure to high levels of asbestos increases the chances of getting two types of cancer: lung cancer and cancer of the thin membrane that surrounds the lung and other internal organs, called mesothelioma. Both types are usually fatal, and develop over a number of years. Breathing asbestos can also increase the chances of getting cancer elsewhere (for example, in the esophagus, stomach, or intestines).

Breathing asbestos can also cause an accumulation of scar-like tissue in the lungs and in the membrane surrounding the lungs. This tissue does not expand and contract like normal lung tissue, making breathing difficult. Blood flow to the lungs may also decline, causing heart enlargement. When the injury is mostly in the lungs, the disease is called asbestosis.

COPPER

What is it?

Copper is a reddish metal that occurs naturally in rock, soil, water, plants, sediment, and air. It is an essential element for all living organisms. Copper is most commonly found in pennies, electrical wiring, and some water pipes. It is also found in many alloys, such as brass and bronze.

Copper is extensively mined and processed and is primarily used as a metal or alloy in making wire, sheet metal, pipe, and other metal products. Copper compounds are most commonly used in agriculture to treat plant diseases, for water treatment, and as preservatives for wood, leather, and fabrics.

How can exposure occur?

Most copper is released to land by mining operations, agriculture, solid waste, and sludge from sewage treatment plants. Copper is released to water from soil and industrial and sewage treatment discharge. Much of this copper is attached to dust and other air particles.

Most copper compounds found in air, water, sediment, soil, and rock are so strongly attached to dust and dirt or embedded in minerals that they don't usually affect health; this is common of copper found at hazardous waste sites. Some copper in the environment, however, is less tightly bound to particles and may be absorbed by plants and animals. Dissolved copper compounds commonly used in agriculture, for example, are more likely to threaten human health.

Copper can enter the body by ingesting water or food, soil, or other substances that contain copper, or by inhaling copper dust or fumes. Drinking water that contains higher levels of dissolved copper is a common pathway. Water can absorb copper from pipes and brass faucets as it sits overnight. The average concentration of copper in tap water ranges from 20 to 75 parts per billion (ppb). The term "parts per billion" is a way of expressing the concentration of a contaminant in a liquid or air. One part per billion is a very small amount—equal to 1 inch in a distance of about 16,000 miles (or one penny in $10 million).

How can it affect human health?

The body is very good at blocking high levels of copper from entering the bloodstream. Copper is necessary for good health, but large daily intakes of copper can be harmful. Long-term exposure to copper dust can irritate the nose, mouth, and eyes, and cause headaches, dizziness, nausea, and diarrhea. Vomiting, diarrhea, stomach cramps, and nausea may occur if you drink water that contains high levels of copper. Although large amounts can cause liver and kidney damage, copper is not known to cause cancer.

LEAD

What is it?

Lead is a bluish-gray metal that occurs naturally in the environment. Lead is found in plants and animals that are used for food, and in air, drinking water, surface waters, and soil.

Lead is mined from ore deposits or is salvaged from recycled scrap metal. It is used in a wide range of products, including batteries, paint, ammunition and various metal products.

How can exposure occur?

Lead exposure results from inhaling air, drinking water, or ingesting foods or soil that contain lead. Children may be exposed to lead by swallowing chips of paint that contain lead – a surprisingly common occurrence.

Until recently, the largest single source of lead in the air was vehicle exhaust. Currently, key sources include emissions from iron and steel production, smelting operations, and lead-acid battery manufacturers. Cigarette smoke is also a source of lead. Most of the lead in water is from lead plumbing and solder in houses and other buildings, lead-contaminated dust and soil carried into water by rain and wind, and wastewater from industries that use lead.

Lead in soil often comes from lead-contaminated wastes in landfills and from fertilizers. Because plants can absorb lead from contaminated soil, food may contain lead as a result.

Lead exposure stems primarily from contact with contaminated dust or water. Lead has been found at over 800 Superfund sites. Lead can enter the body if you breathe air contaminated with lead particles. Nearly all lead entering the lungs moves to the blood and then to other parts of the body. In adults, very little of the lead they ingest enters the blood. In children who swallow food or soil containing lead, however, much more of the lead enters their blood and moves to other parts of their bodies. Relatively small amounts of lead enter the body through the skin. Most lead ingested or inhaled is stored in bone. Since more lead is stored with each new exposure, the level in bones and teeth increases with age. Lead that is not stored in the body is removed in bodily wastes.

How can it affect human health?

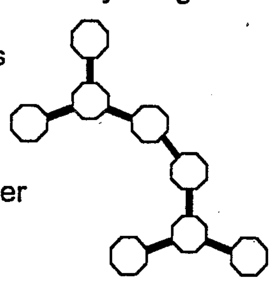
Lead exposure is especially dangerous for fetuses: a woman's exposure during pregnancy can cause premature birth, low birth weight, even miscarriage. Young children are also at greater risk of health damage because their bodies absorb more lead and are more sensitive to its negative effects. Lead exposure in infants and young children can lower IQ scores, stunt physical growth, and cause hearing problems.

Exposure to high levels of lead can cause severe brain and kidney damage, and affect older men's blood pressure and reproductive systems.

POLYCHLORINATED BIPHENYLS (PCBs)

What are they?

PCBs are human-made chemicals of varying toxicity. Because they are good insulators and are nonflammable, PCBs have been widely used as coolants and lubricants in transformers and other electrical equipment. Evidence that PCBs damage the environment and may cause health hazards led to the end of PCB manufacture in the United States in 1977.



How can exposure occur?

Although PCBs are no longer manufactured, human exposure still occurs. Many older transformers, which have a lifespan of at least 30 years, use fluids that contain PCBs. PCBs are very persistent and are widely distributed in the environment. They have been found in over 300 Superfund sites. Levels of PCBs can be found in outdoor air, on soil surfaces, and in water. PCBs can be released into the environment from:

- Poorly maintained hazardous waste sites that contain PCBs
- Illegal or improper dumping of PCB wastes
- Leaks of gases from electrical transformers that contain PCBs
- Disposal of PCB-containing consumer products into municipal rather than hazardous waste landfills.

Eating PCB-contaminated fish can be a major source of exposure. Exposure from drinking water or from breathing outdoor air containing PCBs is less common. Once in the air, PCBs can be carried long distances — they have even been found in snow and seawater in the Antarctic. Contaminated indoor air may also be a major source of human exposure to PCBs.

How can they affect human health?

PCBs can cause such health problems as liver damage, skin irritation, cancer, and reproductive system damage. While the role of PCBs in causing cancer and other health problems in people cannot be clearly demonstrated, research shows there is cause for people to be concerned about PCB exposure.

TRICHLOROETHYLENE (TCE)

What is it?

TCE is a human-made, clear liquid used mainly as a solvent to remove oils and grease from metal during manufacture or maintenance.

How can exposure occur?

Various studies show that between 9 and 34 percent of the nation's water may be contaminated with TCE. It has been found in over 700 Superfund sites. TCE can evaporate from disposal sites into the air or leak into groundwater. It can also evaporate into the air during its production, or from glues, paints, coatings, and other chemicals.

TCE can enter the body by breathing contaminated air, drinking contaminated water, or absorption through the skin.

How can it affect human health?

Dizziness, headaches, slow reflexes, sleepiness, and numbness have occurred in people breathing TCE or using TCE products in poorly ventilated areas. Irritation of the eyes, nose, and throat can also occur if undiluted TCE is ingested. Unconsciousness, or even death, can occur from drinking or breathing higher amounts of TCE. Generally, minor negative effects that result from one or several exposures to TCE disappear when exposure ends.

Some harmful health effects may persist after long-term TCE exposure. Studies show that repeatedly ingesting or breathing high levels of TCE can cause nervous system changes; liver and kidney damage; tumors of the liver, kidney, and lungs; and leukemia.

ZINC

What is it?

Zinc is one of the most widely used metals in the world. It is used both alone, to coat other metals, and combined with other metals to form alloys such as brass and bronze. It also combines with other chemicals such as chlorine to form zinc compounds (zinc chloride). Zinc compounds occur naturally in the air, soil, and water, and are present in all foods. Our bodies need small amounts of zinc, but in large doses it can be harmful.

How can exposure occur?

Zinc mostly enters the environment from smelting and refining operations, and is usually found in surface water and groundwater. Zinc may also enter the soil in discharges from industrial operations and in the natural breakdown of zinc ore deposits. Food is the main source of ingested zinc; other exposure sources include drinking water, contaminated air, and tobacco products.

Zinc is carried into the air as dust and fumes from zinc production facilities, automobile emissions, fuel combustion, and soil erosion. Garbage incineration, coal combustion, and smelters are also major sources of airborne zinc.

Zinc is present in most rocks and in certain minerals. As these materials break down over time, zinc may be released to surface water or groundwater. This source of zinc is diluted and widely dispersed. Rainwater in urban areas, mine drainage, and municipal and industrial wastes are more concentrated sources of zinc in water. Zinc in soil may come from particles that are deposited from the atmosphere, or from sewage treatment sludge. Hazardous waste sites are additional sources of zinc in soil. Zinc has been found in over 700 Superfund sites.

Zinc enters the body through the digestive tract when food or water containing zinc is ingested. It also can enter through the lungs when zinc dust or fumes are inhaled. The most important exposure pathway is likely to be through drinking zinc-contaminated water. Normally, zinc leaves the body in wastes.

How can it affect human health?

Problems with digestion will usually result from eating food or drinking water that contains too much zinc. Stomach cramps, nausea, and vomiting have resulted from ingesting too much zinc. Over an extended period, overexposure to zinc may affect the body's immune system.

FACT FLASH

10: Superfund Community Involvement Program

Community involvement is essential in all Superfund actions taken by the U.S. Environmental Protection Agency (EPA), since the Superfund program is based on the public's rights and concerns in maintaining a safe, healthy environment. Community participation in the Superfund process ensures that citizen concerns are identified and met and that the public is involved in the decisions that affect their health and well-being. Sometimes citizens help decide how contaminated sites will be used after they are cleaned up.

EPA's community involvement program promotes open communication among everyone involved in, or affected by, the Superfund process. The goal is to build trust, to focus on real problems, and to find workable solutions. When the public is actively involved, better cleanup decisions are made and the cleanup process is better understood.

What is community involvement?

Formal community involvement in the cleanup process at a site starts when EPA assigns a community involvement coordinator to the Superfund site. These coordinators facilitate communications and activities so that the public can participate in Superfund decisions that affect their communities. Coordinators have three goals for involving the community:

- Keep the public informed about everything that's going on – what the problems are, what the health risks are, how progress is being made, and any other issues related to the site.
- Give people the chance to provide feedback on decisions.
- Identify and resolve conflicts, keeping the dialogue constructive.

For each Superfund site, the following building blocks for public participation are required:

- Community Relations Plan (CRP)
- Information repositories/ administrative record
- Explanation of planned response and cleanup activities
- Technical Assistance Grants (TAGs)
- Public comment periods
- Response to comments
- Remedial design fact sheet.

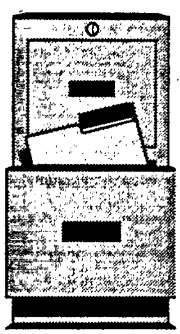
Community Relations Plan

A site-specific Community Relations Plan guides EPA's community involvement efforts during a site cleanup. This plan describes various ways to encourage effective communication between the community and EPA; identifies where the public can attend meetings and find information about the site; describes the site; lists how the community has been involved in the past; and talks about public concerns and interests. It also describes the community involvement activities that will be scheduled. The plan helps both the community and EPA by discussing past events and current concerns.

Technical Assistance Grants (TAGs)

TAGs are $50,000 grants made available to qualified groups of citizens affected by hazardous waste. Grants are given to community groups so they can hire technical advisors who can help explain technical information about a site, or obtain training, supplies, and equipment. Groups eligible to receive this grant money include citizens' associations and environmental or health advocacy organizations.

Information Repository



For each Superfund site EPA creates an information center, called an information repository, that the public can easily use. Typically it is located in a library or town hall. Documents in the repository include site work plans, the Community Relations Plan, investigation studies, a health assessment, the proposed plan for cleaning up the site, sampling reports, fact sheets, and other materials related to the site.

Administrative Record

The administrative record is a file that has all of the technical documents related to the site cleanup, as well as all the public's comments. A copy of the administrative record is kept in the information repository so the public can review it.

Proposed Plan

EPA prepares a proposed plan that discusses what studies have been done at the site, what cleanup options there are, and which cleanup method EPA prefers.

Fact Sheets

EPA distributes a fact sheet that describes the proposed plan and publishes a notice in the newspaper telling people about how they can review it and give input.

Before EPA picks a cleanup remedy, community members can attend a meeting to discuss the plan and give their comments. Citizens have at least 30 days to review and comment on the plan. Public meetings give community members a chance to ask questions or express their opinions and concerns about a proposed remedy.

Responsiveness Summary

At the end of the public comment period, EPA summarizes all questions and comments it received from the public and its response to these comments. This summary, called the responsiveness summary, is included in EPA's Record of Decision (ROD) for the site.

If, as a result of public input, EPA makes a big change in which cleanup method it chooses, it publishes a revised proposed plan to explain the change and either extends or renews the public comment period. EPA then publishes a notice that tells the public which remedy has been selected in the ROD and where they can read the ROD for more details.

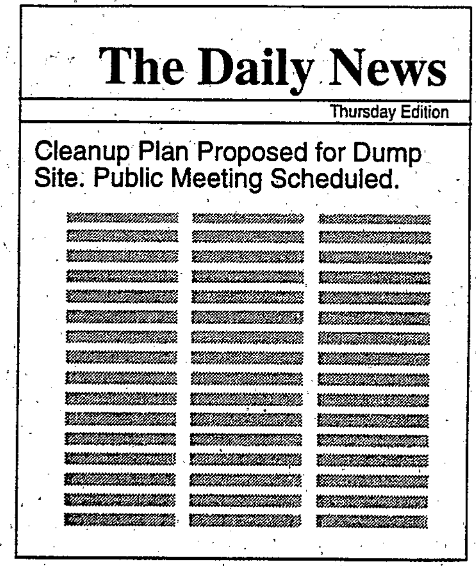
Remedial Design Fact Sheet

Once it selects a remedy, EPA distributes a remedial design fact sheet that explains the technology used to cleanup the site.

What else does EPA do to involve community?

EPA always gets community input when it proposes to add or delete a site from the list of the nation's worst hazardous waste sites, or to include a site in a special research project. EPA also does many other things to make sure the community can get involved and stay informed, including:

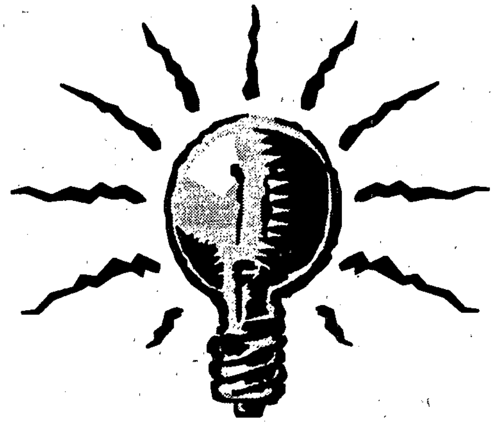
- Produce fact sheets, newsletters, or brochures to give more information about a site or to warn residents about potential health threats, such as eating fish from a contaminated river or lake
- Teach children about Superfund sites and their dangers
- Operate a telephone hotline to answer questions
- Inform the news media about site activities and plans



- Show videos about site activities to community residents and groups
- Help citizens form working groups to influence site decisions
- Conduct site tours and hold open houses so people can learn more about the cleanup process
- Make presentations to local groups and officials about site activities
- Build observation decks so people can watch what's happening at a site
- Conduct door-to-door interviews to collect or share information.

Community Advisory Groups (CAGs) are another way to promote community involvement. CAGs help people, especially low-income and minority groups, participate in the decision making process at Superfund sites. CAGs help communities get recognition, training, guidance, and other support that will help them work with EPA.

Another program is **Technical Outreach Services for Communities (TOSC).** It offers assistance to communities affected by hazardous waste substances but that don't have a TAG. TOSC provides technical information and guidance through relationships with 23 universities across the nation.



What are the benefits of community involvement?

Better cleanup decisions are often made when the public is involved, and the community understands the cleanup process better if they participate. At several sites citizen involvement has changed Superfund cleanups. For example, at a site in New England EPA proposed to clean up contaminated soil by burning it in an incinerator. But the community opposed the remedy and rallied the support of others in the state. Because of their efforts, EPA changed the cleanup remedy. In Montana, community residents wanted to turn part of a Superfund site into a golf course. EPA listened to what the community wanted and worked with everyone involved – as a result, the golf course will be built within the next few years when cleanup is complete.

What can you do to get involved?

To get involved in making decisions about a Superfund site in your community, you can:

- Contact your Community Involvement Coordinator (CIC) and let them know you want to find out more about the site, and ask how you can help
- Call the RCRA, Superfund, and EPCRA Hotline for public materials at 1-800-424-9346
- Start a CAG
- Visit the Site's Information Repository
- Apply for a TAG
- Attend public meetings
- Surf the Internet
- Become involved with environmental groups in your area
- Ask your CIC to give a presentation/ workshop to your community
- Ask your CIC for the TOSC nearest you
- Let EPA know what you think through letters
- Tell others about what you are doing and how they can help.

FACT FLASH

11: Other Major Environmental Laws

Congress has enacted a series of environmental laws that work together to protect our health, our environment, and our future. Some laws are about protecting natural resources, some are about protecting people, and some affect how businesses and governments can act. They all work together to make a cleaner, safer world. Laws set out a framework or a basic outline of what needs to be done. Then a government agency, in this case EPA, writes rules, regulations, and policies to fulfill what the law says should be done. The laws described in this Fact Flash are Federal laws. That means they apply to the entire United States. Each state also has its own laws and its own agencies to implement its laws. Most of the Fact Flashes talk about CERCLA and the Superfund Program. Here are some other important environmental laws.

Resource Recovery and Conservation Act (RCRA)

RCRA controls hazardous waste management from generation through disposal, including the waste generators, transporters, and owners and operators of waste treatment, storage, and disposal facilities. Requirements are enforced through permits that specify the practices and conditions that must be followed by hazardous waste handlers. RCRA applies mainly to tracking and ensuring safe management of hazardous waste from creation to disposal. RCRA works together with Superfund, which addresses the serious problem of abandoned wastes and inactive hazardous waste facilities. Superfund handles the mistakes of the past, and RCRA tries to prevent the creation of new hazardous sites.

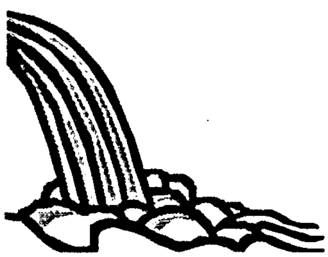
RCRA also regulates solid waste management and the underground storage tank (UST) program. There are nearly two million USTs around the country. USTs can harm the environment through leaks or spills. UST owners and operators must clean up any damage their tanks may have caused. New tanks must also meet stringent standards and be operated to minimize the chance of leaks or spills.

Clean Air Act (CAA)

The Clean Air Act restricts the kinds and amounts of pollutants that may be released into the air by cars, industry, and other sources. The CAA requires states to control air pollution through the use of permits. All air pollution sources must meet emission limits set by state plans. These plans describe the pollution control and permit requirements for new emission sources. The National Ambient Air Quality Standards (NAAQS) are the basis of the CAA program and cover air emission standards for sulfur dioxide, nitrogen oxides, particulate matter, carbon monoxide, ozone, and lead. For each, there is a primary standard that protects human health with an adequate safety cushion, and a secondary, more stringent, standard that better promotes public welfare.

Clean Water Act (CWA)

CWA regulates the pollution that will reach surface waters (rivers, lakes, ponds and streams). Like the CAA, discharge of pollutants from recognized sources is controlled by issuing permits. The law prohibits a point source from discharging pollutants into the water unless the discharge meets certain permit requirements. A point source is generally the point at which a facility discharges wastewater, such as a paper mill emptying wastewater into a creek via a pipe.



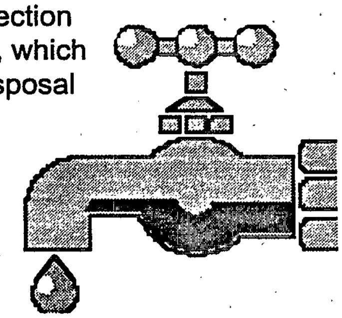
The centerpiece of the CWA is the National Pollutant Discharge Elimination System (NPDES) permit. There are many types of NPDES permits, depending on the type of discharge and the water quality standards being applied to the discharge. The NPDES permit may allow a permittee to discharge an authorized level of a pollutant, but require that any failures to comply with the permit be reported. NPDES permitting is a complex process. The CWA also protects wetlands and provides grants for communities to build sewer treatment plants.

Oil Pollution Act (OPA)

OPA, passed in 1990, establishes liability and compensation rules related to oil spills, and creates a $1 billion supplemental compensation fund for oil spills. OPA focuses on liability and compensation after a spill has occurred, and guides cleanup of contaminated areas. Like Superfund, OPA's fund can be used for cleanups if responsible parties can't or won't do the work themselves.

Safe Drinking Water Act (SDWA)

SDWA ensures that our tap water is fit to drink. Passed in 1974, SDWA sets national drinking water standards for public systems that deliver water to the tap. SDWA also protects groundwater through the underground injection control program, which regulates the disposal of liquid waste in underground wells, and the wellhead protection program, which prevents contamination of areas surrounding public wells.



SDWA is used with RCRA and CERCLA to protect and clean up groundwater by setting water quality standards.

Toxic Substances Control Act (TSCA)

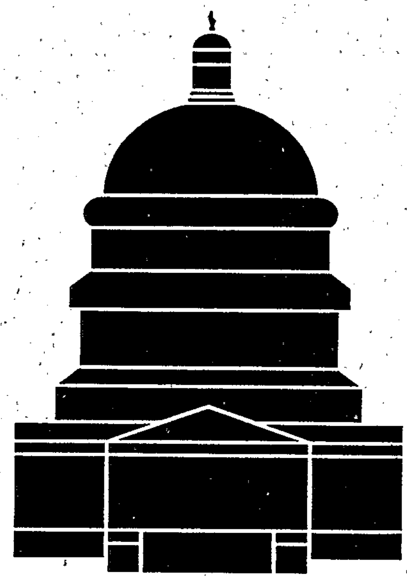
TSCA, passed in 1976, requires tests of chemicals that may harm human health or the environment; reviews of new chemical substances; limits on the availability of some existing chemicals; and import certification standards to ensure that imported chemicals comply with domestic rules. TSCA bars the introduction of chemicals that may pose unreasonable risks to people or the environment, when the risks outweigh possible economic and social benefits. TSCA also regulates existing chemicals, particularly PCBs. For PCBs and a few other chemicals, TSCA prohibits or limits use and regulates handling, storage, and disposal.

Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA)

Passed in 1972, FIFRA regulates the manufacture and use of pesticides and allows EPA to restrict or prohibit use of particularly harmful pesticides.

Emergency Planning and Community Right-to-Know Act (EPCRA)

EPCRA makes sure people have an opportunity to find out what chemical hazards are in a community, and helps communities plan for chemical accidents or incidents. EPCRA requires states to develop plans to prepare for possible chemical accidents or emergencies. It also makes businesses report annually on the chemicals they use and store and the amount of toxic chemicals they have released into the environment. This information is available to the public.



Occupational Safety and Health Act (OSHA)

OSHA sets minimum health and safety standards for the workplace. Private employers must protect their employees by following OSHA requirements. OSHA, RCRA, TSCA, FIFRA, and EPCRA share common reporting and record-keeping requirements, and EPA and OSHA cross-train their inspectors to look for both environmental and OSHA violations.

GLOSSARY

Glossary

These words and phrases are scientific, medical, or environmental terms used in the Haz-Ed materials.

Acid — a solution that has a pH value lower than 7

Acute — occurring only once or more than once within a short period of time

Acute Exposure — a single exposure to a hazardous material for a brief length of time

Administrative Record — a compilation of documents supporting an administrative action; under Superfund, administrative actions often compel Potentially Responsible Parties (PRPs) to undertake or pay for hazardous waste site cleanups

Advection — transportation of contaminants by the flow of a current of water or air

Adverse Health Effect — any effect resulting in anatomical, functional, or psychological impairment that may affect the performance of the whole organism

Anatomical Response — measure of a change in or damage to the anatomy of a species as a result of exposure to a contaminant

Aquifer — an underground rock formation composed of sand, soil, gravel, or porous rock that can store and supply groundwater to wells and springs

Aquitard — a barrier to the flow of groundwater in an aquifer

Assessment — see site assessment

Base — a solution that has a pH value greater than 7

Benthic — relating to or occurring at the bottom of a body of water

Bioaccumulation — the retention and buildup of chemicals or hazardous substances in the bodies of organisms due to repeated exposure or consuming contaminated organisms lower on the food chain

Biochemical Response — measure of a change in or damage to the blood chemistry of a species as a result of exposure to a contaminant

Biological Degradation — as used in the Superfund Program, the process by which biological agents can reduce or eliminate risks posed by a hazardous substance through decomposition into less hazardous components

Biomass — the amount of living matter in a given area, often refers to vegetation

Blood Enzyme Level — measure of a change in the enzymes normally present in the blood of a species as a result of exposure to a contaminant

Carcinogen — a substance or agent that may produce or increase the risk of cancer

Chronic Exposure — continuous or repeated exposure to a hazardous substance over a long period of time

Clay Soil — soil composed chiefly of fine particles

Clean Air Act — gives EPA authority to set standards for air quality and to control the release of airborne chemicals from industries, power plants, and cars

Cleanup — the process of removing, treating, or disposing of contaminants at a site and restoring the site to a condition that is not dangerous to people or the environment

Clean Water Act — a Federal law that controls the discharge of pollutants into surface water in a number of ways, including discharge permits

Community — an interacting population of various types of individuals (or species) in a common location; a neighborhood or specific area where people live

Community Involvement —a process in which the concerns of local citizens are addressed during the Superfund process

Composting — the decomposition of yard waste and vegetable scraps into organic material

Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) — enacted in 1980 and nicknamed Superfund, this law provides the authority through which the Federal government can compel people or companies responsible for creating hazardous waste sites to clean them up. It also created a public trust fund, known as the Superfund, to assist with the cleanup of inactive and abandoned hazardous waste sites or accidentally spilled or illegally dumped hazardous materials.

Concentration — the amount of one material dispersed or distributed in a larger amount of another material

Condensation — a part of the hydrologic cycle during which water vapor turns into a liquid

Confined Aquifer — an aquifer bounded on the top by confining materials such as rock formations

Contaminant — harmful or hazardous matter introduced into the environment

Contaminant Level — a measure of how much of a contaminant is present

Contamination — the introduction of harmful or hazardous matter into the environment

Corrective Action — cleanup of hazardous waste contamination at non-Superfund sites

Corrosive — capable of chemically wearing substances away (corroding) or destroying them

Deep-Well Injection — injection of hazardous wastes into deep wells underground

Dense Non-Aqueous Phase Liquid (DNAPL) — liquid contaminants that are relatively insoluble and heavier than water; also known as "sinkers" because they will sink to the bottom of an aquifer, where they become especially difficult to detect and clean up

Discharge Areas — locations where groundwater flows or is discharged to the surface

Discovery — the initial activity in the Superfund process where a potentially contaminated site is reported to EPA or a similar state or local agency

Diversity — variety; differences among and within species

Early Action — a response action that addresses the release or possible release of hazardous substances and can be resolved within a short period of time

Ecology — study of the relationships of living organisms to each other and to their environment

Ecosystem — a specialized community, including all the component organisms, that forms an interacting system; for example, a marsh, a shoreline, a forest

Emergency — a situation or occurrence of a serious nature that develops suddenly and unexpectedly and demands immediate action

Emergency Response — a response action to situations that may cause immediate and serious harm to people or the environment

Environment — totality of conditions surrounding an organism

Environmental Risk — likelihood, or probability, of injury, disease, or death resulting from exposure to a potential environmental hazard

Epidemiology — study of causes of disease or toxic effects in human populations

Estuary — region of interaction between rivers and near-shore ocean waters, where tidal action and river flow create a mix of fresh and salt water; may include bays, mouths of rivers, salt marshes, and lagoons; brackish water ecosystems; may shelter and feed marine life, birds, and wildlife

Evaporation — a part of the hydrologic cycle during which liquid water turns into water vapor

Exposure — coming into contact with a substance through inhalation, ingestion, or direct contact with the skin; may be **acute** or **chronic**

Fauna — animal life

Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA) — a Federal law that requires labels on pesticides that provide clear directions for safe use; FIFRA also authorizes EPA to set standards to control how pesticides are used

Fertilizers — nitrogen- and phosphate-rich chemical compounds that are used to increase the productivity of croplands; fertilizer production usually includes the use and disposal of petrochemicals

Flora — plant life

Fresh Water — water resources free from salt that are critical to living organisms; 3 percent of the water on Earth is fresh (the rest is salt water), and 95 percent of fresh water resources are groundwater

Groundwater — water found beneath the Earth's surface that fills pores between materials, such as sand, soil, or gravel

Habitat Encroachment — term used to describe the way natural habitats are destroyed as human development of new areas continues to grow and expand, or pollution damages the environment

Hazard Ranking System (HRS) — the method EPA uses to assess and score the hazards posed by a site that takes into account the nature and extent of contamination and the potential for the hazardous substances to migrate from the site through air, soil, surface water, or groundwater; HRS scores are used to determine whether a site should be placed on the National Priorities List (NPL)

Hazardous Chemical — see Hazardous Substance

Hazardous Material — see Hazardous Substance

Hazardous Substance — a broad term that includes all substances that can be harmful to people or the environment; toxic substances, hazardous materials and other similar terms are subsets of hazardous substances

Hazardous Waste — by-products or waste materials of manufacturing and other processes that have some dangerous property; generally categorized as corrosive, ignitable, toxic, or reactive, or in some way harmful to people or the environment

Health Risk Assessment — scientific evaluation of the probability of harm resulting from exposure to hazardous materials

Heavy Metals — metals such as lead, chromium, copper, and cobalt that can be toxic at relatively low concentrations

Histopathological Test — test that examines the structure of cells and tissues to determine if any damage has been caused by exposure to a contaminant

Hydrologic Cycle — the process of evaporation, transpiration, condensation, precipitation, infiltration, runoff, and percolation in which water molecules travel above, below, and on the Earth's surface

Ignitable — capable of bursting into flames easily

Infiltration — the movement of water through the ground surface into the unsaturated zone

Information Repository — a set of current information, technical reports, and reference documents regarding a Superfund site; it should be located in a public building that is convenient for local residents, such as a public school, city hall, or public library

Innovative Treatment Technologies — remedies that have been tested, selected, or used for treating hazardous waste or contaminated materials but don't have much information on cost and performance

Inorganic Compounds — chemical compounds that do not contain carbon, usually associated with life processes; for example, metals are inorganic

Landfill — a location for the disposal of wastes on land designed to protect the public from hazards in waste streams; **sanitary landfills**, designed to receive municipal solid waste, are distinguished from **hazardous waste landfills**, designed to isolate hazardous substances

Liability — under Superfund, a party responsible for the presence of hazardous waste at a site is also legally responsible for acting and paying to reduce or eliminate the risks posed by the site

Light Non-Aqueous Phase Liquid (LNAPL) — liquid contaminants that are relatively insoluble and lighter than water; also known as "floaters" because they will float on top of an aquifer

Long-Term Action — a response action that eliminates or reduces a release or threatened release of hazardous substances that is serious but not an immediate danger to people or the environment and may take years to complete (also known as a remedial action)

Migration — as used in the Superfund program, the movement of a contaminant; actual or potential migration is one measure of the dangers created by a contaminant

Migration Pathways — the routes a contaminant may move around in the environment (*e.g.*, soil, groundwater, surface water, air)

Municipal Solid Waste — garbage that is disposed of in a sanitary or municipal solid waste landfill

Mutagenic — causing alteration in the DNA (genes or chromosomes) of an organism

National Priorities List (NPL) — EPA's list of the most serious uncontrolled or abandoned hazardous waste sites, identified as candidates for long-term action using money from the Superfund trust fund

Organic Compounds — chemical compounds that contain carbon, an element usually associated with life processes

Percolation — the movement of groundwater from the unsaturated zone to the saturated zone

Permeability — the degree to which groundwater can move freely through an aquifer measured by the interconnection of pores and fractures

Pesticides — chemical compounds used to control insects and other organisms that may reduce agricultural productivity; most are **toxic**

pH — a measurement of the acidity or alkalinity level of a solution

Physiological Response — measure of physical change or damage in a species as a result of exposure to a contaminant

Plume — an area of groundwater contamination

Pollution Prevention — a strategy that emphasizes reducing the amount of pollution or waste created, rather than controlling waste or dealing with pollutants after they have been created

Population — group of similar individuals living in the same general area

Pore — an open space in rocks and soils

Porosity — the ability of rock material to store water

Potentially Responsible Parties (PRPs) — any individual or company potentially responsible for, or contributing to, contamination at a Superfund site

Precipitation — a part of the hydrologic cycle during which condensed water vapor in the air falls to the ground in the form of rain, snow, sleet, and so forth

Preliminary Assessment (PA) — the process of collecting and reviewing available information about a known or suspected hazardous waste site or release that is used to determine if the site requires further study

Probability — chance that a given event will occur

Proposed Plan — a plan for cleaning up a Superfund site submitted by EPA and subject to public comments

Ratio — the relationship in quantity, amount, or size between two or more things

Reactive — one of four categories of hazardous waste; substances capable of changing into something else in the presence of other chemicals, usually violently or producing a hazardous by-product

Recharge Areas — areas where infiltration to aquifers occurs

Record of Decision (ROD) — a public document that explains the cleanup method that will be used at a Superfund site, based on EPA studies, public comments, and community concerns

Recycling — the reuse of products or by-products or other materials that could become wastes if discarded instead of being used

Relative Abundances — measure of the population of one species in an ecosystem as compared to other species within that same ecosystem; number of individuals in any given species compared to the total number of individuals in the community

Release — when a hazardous substance goes from a controlled condition (for example, inside a truck, barrel, storage tank, or landfill) to an uncontrolled condition in the air, water, or land

Residual Contamination — contaminants left at a site after the risks posed by the site have been reduced and the site no longer threatens people or the environment, or that currently is not possible to remove

Resource Conservation and Recovery Act (RCRA) — a Federal law that authorizes EPA to set standards for companies producing, handling, transporting, storing, and disposing of hazardous waste

Response Action — an action taken by EPA or another Federal, state, or local agency to address the risks posed by the release or threatened release of hazardous substances — generally categorized as Emergency Responses, Early Actions, and Long-Term Actions

Responsible Party — a person or business that is responsible for a hazardous site; whenever possible, EPA requires Responsible Parties, through administrative and legal actions, to clean up the sites they have contaminated

Risk — likelihood or probability of injury, disease, or death

Runoff — the amount of precipitation that runs over the ground surface and returns to streams, rivers, or other surface water bodies. It can collect pollutants from air or land and carry them to receiving waters

Safe Drinking Water Act (SDWA) — a Federal law that authorizes EPA to set national standards for drinking water and gives EPA authority to control the disposal of hazardous waste into groundwater

Sampling — the collection of representative specimens analyzed to characterize site conditions

Saturated Zone — an underground geologic layer in which all pores and fractures are filled with water

Saturation — the degree to which a geologic formation is filled with water

Site Assessment — the process by which EPA determines whether a potential Superfund site should be placed on the National Priorities List (NPL); it can consist of a Preliminary Assessment (PA) or a combination of a PA and a Site Inspection (SI)

Site Cleanup — see Cleanup

Site Discovery — see Discovery

Site Inspection (SI) — a technical phase of the Superfund process, following the Preliminary Assessment (PA), during which EPA gathers information (including sampling data) from a site needed to score the site using the Hazard Ranking System (HRS) to determine whether the site should be placed on the National Priorities List (NPL)

Solvents — chemical products that are used to dissolve other compounds; typically found in cleaners and used in petrochemical processes

Sorption — a process in which something is taken up and held; as used in the Superfund Program, sorption refers to technologies that use a sorption agent that attracts, takes up, and holds hazardous waste for removal

Source Reduction — the design, manufacture, or use of products that in some way reduces the amount of waste that must be disposed of; examples include reuse of by-products, reducing consumption, extending the useful life of a product, and minimizing materials going into production

Source Separation — the segregation of hazardous materials from nonhazardous materials to reduce the volume of hazardous waste that must meet special removal and disposal requirements; it is a method used by industry to control costs

Species Richness — number of species in a community

Superfund — see CERCLA

Superfund Trust Fund — a public trust fund created with passage of the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) in 1980 to be used to help pay for the cleanup of abandoned hazardous waste sites

Surface Impoundments — lined ponds storing hazardous waste

Surface Water — bodies of water that form and remain above ground, such as lakes, ponds, rivers, streams, bays, and oceans

Technical Assistance Grant (TAG) — funds given to communities for the purpose of hiring advisors to interpret technical information related to the cleanup of Superfund sites

Toxic — poisonous

Toxic Substances Control Act (TSCA) — a Federal law that empowers EPA to require the chemical industry to test chemicals and provide safety information before they are sold

Toxicology — study of the effects of poisons in living organisms

Transpiration — a part of the hydrologic cycle in which water vapor passes out of living organisms through a membrane or pores

Treatment Technologies — processes applied to hazardous waste or contaminated materials, to permanently alter their condition through chemical, biological, or physical means, and reduce or eliminate their danger to people and the environment

Unconfined Aquifer — an aquifer not bound by confining material

Underground Storage Tank — an underground tank storing hazardous substances or petroleum products

Unit of Measure — a predetermined quantity (as of length, time, or heat) adopted as a standard of measurement

Unsaturated Zone — an underground geologic layer in which pores and fractures are filled with a combination of air and water

Volatile Organic Compounds (VOCs) — organic (carbon-based) compounds that evaporate at room temperature

Waste-to-Energy Incinerator — a process unit designed to burn solid, liquid, or gaseous materials under controlled conditions to reduce waste volume and produce energy

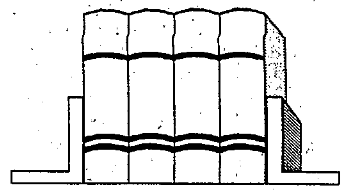
Water Table — the upper limit of a geologic layer wholly saturated with water

Water Table Aquifer — an unconfined aquifer in which the water table can rise and fall

Well — a hole sunk into the ground to reach a supply of water

SUGGESTED READING

Suggested Reading



These suggested readings—books, periodicals, and other materials—provide further information on the topics discussed in the Haz-Ed materials. Each reading is cross-referenced to the most appropriate Haz-Ed warm-ups, activities, and grade levels. The abstract provides a thumbnail sketch of the resource. A limited number of Spanish-language documents are included.

The documents listed are available from local public, school, or university libraries or, where noted, available free of charge from the referenced sources. EPA also offers other documents on selected Superfund and RCRA topics for purchase. For more information on available documents, please call the RCRA/UST, Superfund, and EPCRA Hotline at (800) 424-9346, between 9:00 AM and 6:00 PM (EST). Free documents available through the Hotline will take three to five weeks to arrive.

Each entry in this list is presented in the following format.

Reference, Abstract	Suggested Grade Level ## Related Warm-Ups Ⓦ Related Activities Ⓐ

Hazardous Substances: A Reference; Berger, Melvin; Hillside, NJ: Enslow Publishers (1986); 128 pgs.

7-12 — Ⓦ 2,3 — Ⓐ 1-3, 5-7

A plain-language dictionary providing a general understanding of hazardous substances, with entries on field terms, federal laws and agencies, hazardous substances, and selected chemical accidents. The entry for each chemical describes its composition and nature, how it is used and produced, where it is found, and health effects information. Covers specific chemicals and elements (e.g., toluene, mercury) as well as broader categories (e.g., heavy metals).

"Superfund Reauthorization Opens Door to Change;" Clay, Don; Nation's Cities Weekly; 15: February 24, 1992; p. 5.

9-12 — Ⓦ 1,5 — Ⓐ 9, 12

This article from Don Clay, the former U.S. EPA Assistant Administrator for the Office of Solid Waste and Emergency Response, summarizes the accomplishments, successes, and shortcomings of the Superfund program in light of pending program reauthorization.

Reciclemos en Casa: Guía Práctica para Reciclar en el Hogar (Recycling at Home: A Practical Guide); Clean Pearland.

7-12 — Ⓦ 5 — Ⓐ 1,3,11, 13

Provides information on recycling household wastes in Spanish. Available from Clean Pearland, (214) 485-2411, extension 227.

Reference, Abstract	Suggested Grade Level ## Related Warm-Ups Ⓦ Related Activities Ⓐ

Fighting Toxics: A Manual for Protecting Your Family, Community, and Workplace; Cohen, Gary and John O'Connor, ed.; Washington, D.C.: Island Press (1990); 346 pgs.

10-12 — Ⓦ 2,4,5 — Ⓐ 1,4,5,7 11-13

Although activist in tone, this book contains two chapters providing useful general information. Chapter four describes how to obtain information on hazardous chemicals used and hazardous wastes generated in a community, highlighting EPA's Toxics Release Inventory (TRI) and the Freedom of Information Act (FOIA) process. Chapter seven addresses federal laws designed to prevent or limit pollution of the environment: EPCRA, Superfund, and RCRA.

"Is Your School a Dumping Ground? Hidden Hazards You Can Identify and Eliminate;" Cronin-Jones, Linda; The Science Teacher; 59: October 1992; p. 26-31.

7-12 — Ⓦ 2,4 — Ⓐ 1,5,7 10,11

This article describes an experiment science teachers can use to illustrate how common hazardous wastes are. Student teams discover and identify where hazardous substances (e.g., cleaners and solvents) are stored and discuss safe disposal options and less hazardous product alternatives. Available from the National Science Teachers Association, (703) 243-7100.

Garbage and Recycling; Gay, Kathlyn; Hillside, NJ: Enslow Publishers (1991); 128 pgs.

7-10 — Ⓦ 2,5 — Ⓐ 1,10, 11,13

Provides information on garbage generation, highlighting the problems created by the waste and promoting recycling as a partial solution to the problem. Extensive discussion of recycling paper, scrap metal, plastics, tires, and other materials. Chapter seven examines the management of hazardous waste, discussing RCRA, TRI, and Superfund. Pages 75-77 concentrate on how household hazardous wastes contribute to the problem and discuss solutions.

Water Pollution; Gay, Kathlyn; New York: Franklin Watts (1990); 144 pgs.

9-10 — Ⓦ 6 — Ⓐ 1,2,3 5,6,9

Discusses threats to water resources from several pollution sources. Chapter two discusses in detail threats to groundwater from industrial, municipal, urban, and agricultural sources as well as leaking landfills and hazardous waste dump sites. Pages 20-21 discuss how pollutants from various sources get into the groundwater and what happens to them when they get there. Students with a basic understanding of groundwater will find this discussion useful.

Reference, Abstract	Suggested Grade Level	##
	Related Warm-Ups	Ⓦ
	Related Activities	Ⓐ

"Neighborhood Prepares to Move for Cleanup of Toxic Black Goo;" Haldane, David; Los Angeles Times; June 28, 1994; p. A3.

7-12 | Ⓦ 1,4,5 | Ⓐ 1-2,4-7

Provides a good case study of how a Superfund site is created, demonstrating how contaminated sites can develop over many years.

"Hazardous Wastes at Home: Handle With Care;" Consumer Reports; 59: February 1994; p. 101.

7-12 | Ⓦ 2,4 | Ⓐ 1,3,5 7,11

Useful article detailing the types of hazardous wastes commonly found in the home, how they should be managed, and less toxic alternatives to common household products (e.g., cleaners, solvents, polishes). Part of a larger section on recycling.

Our Endangered Planet: Groundwater; Hoff, Mary; Minneapolis, MN: Lerner Publications (1991); 64 pgs.

7-9 | Ⓦ 6 | Ⓐ 2,3,5,6

Discusses in simple terms the basics of groundwater: where it is found, how it fits into the water cycle, how it is used, and how it is polluted. A glossary provides basic groundwater terms. Includes examples of young people involved in groundwater protection.

"Using the Allium Test to Detect Environmental Pollutants;" Kendler, Barry and Helen Koritz; The American Biology Teacher; 52: September 1990; p. 372.

7-12 | Ⓐ 6

Describes a science experiment students can conduct to learn about the detection of pollutants in organisms. Available from the National Association of Biology Teachers, (703) 471-1134.

Managing Toxic Wastes; Kronenwetter, Michael; Englewood Cliffs, NJ: Julian Messner (1989); 118 pgs.

7-12 | Ⓦ 1,2,5 | Ⓐ 1-6, 9-12

An excellent, broad-based introduction to the management of hazardous wastes, including chemical and elemental hazards, horror stories of hazardous waste disasters, causes of the problem, and what steps are being taken to solve the problem and prevent future disasters. Chapter two covers the story of the Love Canal, NY, hazardous waste dump, including the origins of the problem, how the community was affected, and what the government did to correct the problem. Chapter five examines the parties – public, private, and individual – who contribute to the creation of hazardous waste sites. Chapter seven explains regulatory efforts undertaken by the federal government to deal with the management of hazardous wastes, including RCRA and EPCRA. Chapter eight is devoted entirely to the Superfund program; its genesis, development, and progress.

Reference, Abstract	Suggested Grade Level	##
	Related Warm-Ups	(W)
	Related Activities	(A)

The Future for the Environment; Lambert, Mark; New York: Bookwright Press (1986); 48 pgs.

7-9 — (A) 5,6,13

Provides a basic perspective on how pollution issues may be dealt with in the students' future, presenting a forward-looking discussion of environmental problems, causes, and possible solutions. Does not directly deal with hazardous waste disposal or chemical accidents.

Technological Risk; Lewis, H.W.; New York: W.W. Norton & Co (1990); 353 pgs.

9-12 — (W) 4; (A) 7

Discusses the nature of risk and risk assessment, examples of risk, and, briefly, general rules of statistics and probability. Provides information to allow students to distinguish between perceived and actual risks posed by different activities, substances, and occurrences. Includes clear, basic technical discussion of the science of risk assessment and how governments use the information to protect public health and welfare. Includes two chapters on the risks posed by hazardous chemicals.

Design For a Livable Planet: How You Can Clean Up the Environment; Naar, Jon; New York: Harper & Row (1990); 338 pgs.

11-12 — (W) 1; (A) 1,3,5, 11,12

A guide to citizen action to help prevent environmental pollution. Chapter two addresses hazards posed by mismanagement of hazardous waste, including chemical accidents, and a description and critical assessment of the Superfund program. Examines U.S. environmental laws, including RCRA, Superfund, and EPCRA. Chapters include a list of actions citizens can take.

"A Superfund Success: Toxic Texas Lagoon 'Bio'-Cleaned;" Pendelton, Scott; The Christian Science Monitor; November 4, 1994; p. 7.

7-12 — (W) 1,5; (A) 2,8,9

Provides good contrast to more critical articles on Superfund. It discusses a Superfund site cleaned up by a cooperative venture of responsible parties, and includes discussion of innovative technologies.

Living in a Risky World; Pringle, Laurence; New York: Morrow Junior Books (1989); 105 pgs.

7-9 — (W) 4; (A) 7

Discusses the concept of risk in very basic terms, such as the risks entailed in living daily life, with only limited discussion of the science of risk assessment. Chapter three deals with identifying hazards and measuring risks (largely through examples), how scientists assess the nature and probability of a risk, and how that probability is communicated. Includes a potentially disturbing picture of a scientist injecting a rat. Chapter four looks at how the government uses risk assessment to create laws and regulations to protect the public.

Reference, Abstract	Suggested Grade Level ## / Related Warm-Ups (W) / Related Activities (A)

Environmental Politics and Policy, Second Edition; Rosenbaum, Walter A.; Washington, D.C.: CQ Press (1991); 336 pgs.

10-12 — (W) 1,4,6 — (A) 1,3,7, 12

This book examines the formulation of environmental policy. Chapter seven and pages 44-52 discuss the management and regulation of hazardous wastes, including the structure, successes, and failures of Superfund and RCRA. Chapter five critically examines risk assessment, from the scientific bases to regulatory applications. There is brief discussion of groundwater (pp. 41-43, 202-206) which provides useful information on specific sources of groundwater contamination and the various agencies involved in protecting groundwater. Pages 97-108 list the various Federal agencies responsible for environmental protection and discuss how they work.

Boletin Ambiental: Las Alternativas Menos Toxicas (Environmental Bulletin: Less Toxic Alternatives to Household Cleaning Products); Texas Natural Resource Conservation Commission.

7-12 — (W) 2 — (A) 1,3,11

Describes less hazardous alternatives to standard commercial household cleaning products in Spanish. Available from the Clean Texas 2000 Information Center, (800) 648-3927.

1993 Toxics Release Inventory Public Data Release, Executive Summary; 1995; U.S. EPA; 745-S-95-001.

9-12 — (W) 1,4 — (A) 1,5-7 11

Summarizes national and state data for 1993. Includes an overview of the TRI program, the quantity and type of chemicals released into the environment, and an assessment, by environmental medium, of which states had the largest releases. Available free from the RCRA/UST, Superfund, and EPCRA Hotline, (800) 424-9346.

1993 Toxics Release Inventory Public Data Release, State Fact Sheets; U.S. EPA; 1995; 745-F-95-002.

9-12 — (W) 1,4 — (A) 1,5-7 11

Provides 1993 toxic release data by state, including the top five chemicals released into the environment and the top ten releasing facilities for each state. Available free from the RCRA/UST, Superfund, and EPCRA Hotline, (800) 424-9346.

Characterization of Municipal Solid Waste in the United States: 1994 Update: Executive Summary; U.S. EPA; 1994; 530-S-94-042.

7-12 — (W) 2 — (A) 1,3

Summarizes a study of municipal solid waste (MSW) that includes data from 1960 to 1993. Summary characterizes MSW generation and management to the year 2000. Available free from the RCRA/UST, Superfund, and EPCRA Hotline, (800) 424-9346.

Reference, Abstract	
Suggested Grade Level	##
Related Warm-Ups	Ⓦ
Related Activities	Ⓐ

Chemical Releases and Chemical Risks; U.S. EPA; 1989; 560-2-89-003.

Explains how the Toxics Release Inventory (TRI) can be used to understand chemical risks faced by a community. Available free from the RCRA/UST, Superfund, and EPCRA Hotline, (800) 424-9346.

9-12 | Ⓦ 1,4 | Ⓐ 1,5-7, 11

Chemicals In Your Community: A Guide to EPCRA; U.S. EPA; 1988; 550-K-93-003.

An introductory guide to the EPCRA program. Available free from the RCRA/UST, Superfund, and EPCRA Hotline, (800) 424-9346.

9-12 | Ⓦ 1,4 | Ⓐ 1,5-7, 11

Consumer's Handbook for Reducing Solid Waste; U.S. EPA; 1992; 530-K-92-003.

Discusses amount and types of wastes generated by the average household, both municipal solid waste (garbage) and household hazardous waste. Tips on recycling and safe handling of hazardous wastes are included. Available free from the RCRA/UST, Superfund, and EPCRA Hotline, (800) 424-9346. Also available in Spanish.

7-12 | Ⓦ 2 | Ⓐ 1,3,11

Does Your Business Produce Hazardous Wastes? Many Small Businesses Do; U.S. EPA; 1990; 530-SW-90-027.

For 18 common small businesses, delineates the types of hazardous substances commonly used in that industry. A useful tool for determining the types of hazardous wastes generated by the businesses in the students' community. Available free from the RCRA/UST, Superfund, and EPCRA Hotline, (800) 424-9346.

7-12 | Ⓦ 2 | Ⓐ 1,3,11

Facility Pollution Prevention Guide; U.S. EPA; 1992; EPA/600/R-92/088.

Explains in detail how manufacturing and other facilities can reduce the amount and toxicity of wastes they produce. Designed for facility managers and pollution prevention officers, this document provides additional insight into steps that facilities can take to reduce pollution. Available free from EPA's Office of Research and Development (ORD), (513) 569-7562.

11-12 | Ⓦ 2 | Ⓐ 1,3,10, 11

Hazardous Substances In Our Environment: A Citizen's Guide to Understanding Health Risks and Reducing Exposure; U.S. EPA; 1990; 230-9-90-081.

Discusses development and application of risk and exposure assessments and how the government and community organizations can reduce that risk. Available free from the RCRA/UST, Superfund, and EPCRA Hotline, (800) 424-9346.

9-12 | Ⓦ 4 | Ⓐ 5,7,11

Reference, Abstract	
Suggested Grade Level	##
Related Warm-Ups	(W)
Related Activities	(A)

<u>Household Hazardous Waste Management: A Manual for One-Day Community Collection Programs</u>; U.S. EPA; 1993; 530-R-92-026.

Helps communities plan for one-day, drop-off household hazardous waste (HHW) collection programs. Provides community leaders with guidance on all aspects of planning, organizing, and publicizing an HHW collection program. Available free from the RCRA/UST, Superfund, and EPCRA Hotline, (800) 424-9346.

7-12 — (W) 2 — (A) 1,11 13

<u>Household Hazardous Waste: Steps to Safe Management</u>; U.S. EPA; 1993; 530-F-92-031.

Describes household hazardous waste and the dangers of improper disposal. Urges homeowners to reuse, recycle, and properly manage household hazard wastes. Available free from the RCRA/UST, Superfund, and EPCRA Hotline, (800) 424-9346.

7-12 — (W) 2 — (A) 1,11 13

<u>1993 Biennial RCRA Hazardous Waste Report: Executive Summary</u>; U.S. EPA; 1995; 530-S-95-039.

Summarizes EPA's report based on 1993 data collected from hazardous waste large quantity generators and treatment, storage, and disposal facilities. Includes information about generation, management, and final disposition of hazardous waste regulated by RCRA. Available free from the RCRA/UST, Superfund, and EPCRA Hotline, (800) 424-9346.

7-12 — (W) 2 — (A) 1,3

<u>SARA Title III Fact Sheet</u>; U.S. EPA; 1993; 550-F-93-002.

This fact sheet summarizes the Emergency Planning and Community Right-to-Know Act (EPCRA) program. Available free from the RCRA/UST, Superfund, and EPCRA Hotline, (800) 424-9346.

9-12 — (W) 1,4 — (A) 1,5-7 11

<u>El Programa de Superfund: Guia Ciudadana de Programa de Superfund de la EPA</u>; U.S. EPA; 1994; EPA 540-K-94-002; PB 95-963205.

A Spanish-language version of the pamphlet summarizing the Superfund program and process that is included in the Haz-Ed materials package. The document is available free of charge from NTIS, (703) 487-4650.

9-12 — (W) 1 — (A) 2,4 7-9,12

<u>Environmental Policy in the 1990s, second edition</u>; Vig, Norman and Michael E. Kraft, ed.; Washington, D.C.: CQ Press (1994); 422 pgs.

Discusses how public environmental policy has changed since the 1970s, and where it is headed. Examines the relationship between federal and state environmental attitudes, policies, and regulations. Discusses the development of the current Federal/state power relationship, and predicts the likely consequences of transferring

11-12 — (W) 1,4,6 — (A) 3,7-9 12,13

Reference, Abstract	Suggested Grade Level ## / Related Warm-Ups (W) / Related Activities (A)

regulatory authority to states. Examines different methods of evaluating the successes and failures of major environmental policy initiatives, including a critical assessment of the Superfund program. Provides an excellent and sophisticated discussion of risk-based decisionmaking, including a good explanation of the elements of a risk assessment and how regulators act on those assessments in making laws, policies, and site-specific determinations.

Water: No Longer Taken For Granted; VonBrook, Patricia, et al, ed.; Wylie, TX: Information Press (1989); 92 pgs.

9-12 — (W) 6 — (A) 1,2,5,6

Provides a broad assessment of water and water pollution, including the nature of water, where it is found, how it is used, and how different types of water pollution affect the environment and humans. Explains the nature and uses of groundwater in an easy-to-understand fashion, discussing groundwater flow, aquifers, and characterization and common sources of groundwater contamination, using tables and maps to illustrate and develop main ideas. Pages 44-47 address groundwater pollution from hazardous waste sources, including Superfund sites.

In Our Backyard: A Guide to Understanding Pollution and its Effects; Wagner, Travis; New York: Van Nostrand Reinhold (1994); 320 pgs.

7-12 — (W) 1,2,6 — (A) 1,5,6 8,9,12

This exceptional book examines different types, sources, and effects of pollution, using a simple, accessible question and answer format to explain the many aspects of environmental pollution and what activities can be and are undertaken to remedy the problem. Chapter 3 provides an excellent discussion of the nature and activity of groundwater, examining the diverse sources of contamination and explains how contaminated groundwater is cleaned up and the impediments to such remediation, providing many clear and helpful graphics to illustrate key points. Chapter 5 gives extensive treatment to the facets of waste management: identification, storage, treatment, and disposal. The Superfund process is clearly explained on pages 139-142. Chapter 8 lists the sources of household pollution affecting human health both within and outside the home. Appendix I lists health effects for almost 100 different substances, from asbestos to gasoline to toluene.

"Going Around in CERCLA;" Waite, David; American City & County; 108: August 1993; p. 58.

11-12 — (W) 1 — (A) 1,12

A case study of Superfund liability and cost recovery, controversial issues in the Superfund program. Includes discussion of how household hazardous wastes contribute to potential Superfund sites.

CONTACTS AND RESOURCES

Contacts & Resources

While many topics related to hazardous waste and the Superfund Program are discussed and explained in the Haz-Ed materials and in the suggestions for further reading, you may have questions that are not addressed, or need additional resources to support classroom activities. The following list of contacts and resources may help you answer these questions and locate supplemental resources.

EPA Regional Superfund Community Involvement Coordinators

EPA's Community Involvement Coordinators can provide you with information on local Superfund sites, the location of the administrative records for local Superfund sites, date and location of local public meetings, and ways in which a citizen can file a petition to have a potentially contaminated site investigated. Each EPA Region has a coordinator:

Region 1 **(617) 565-3425**

Region 2 **(212) 637-3675**

Region 3 **(215) 597-9905**

Region 4 **(404) 347-3555 x6264**

Region 5 **(312) 886-6685**

Region 6 **(214) 665-6617**

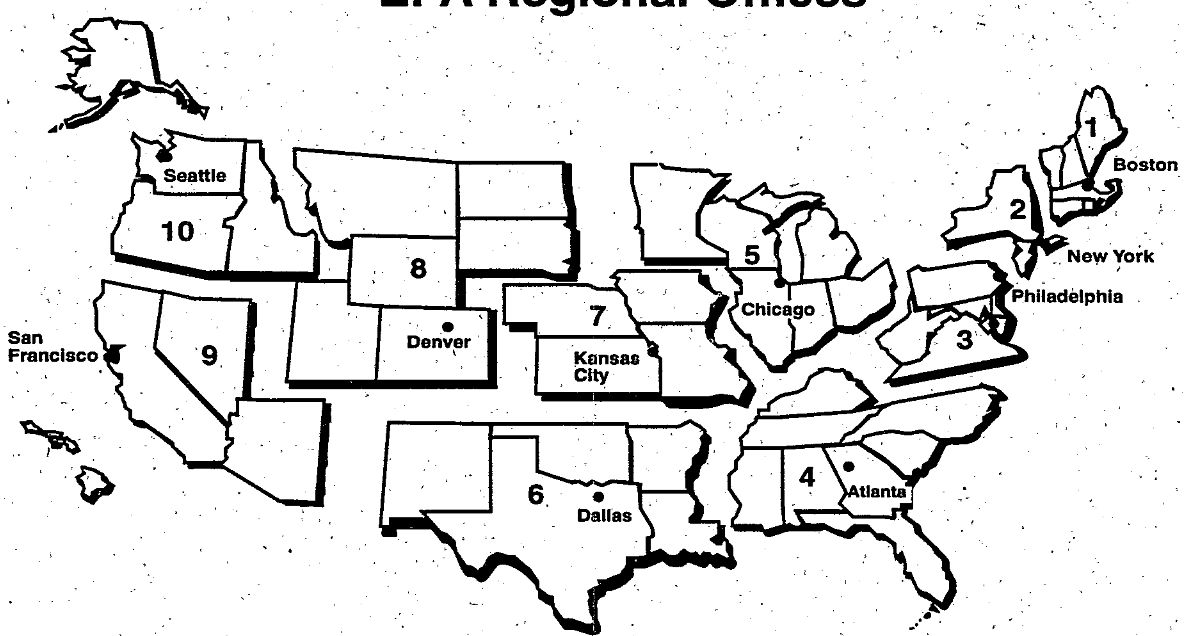
Region 7 **(913) 551-7003**

Region 8 **(303) 312-6600**

Region 9 **(415) 744-2175**

Region 10 **(206) 553-1272**

EPA Regional Offices



State Hazardous Waste Offices

Your state's hazardous waste office can give you information about hazardous waste management programs in your community.

AL	(334) 271-7737
AK	(907) 465-5168
AZ	(602) 207-4105
AR	(501) 682-0831
CA	(800) 618-6942
CO	(303) 692-5575
CT	(203) 424-3023
DE	(302) 739-3689
DC	(202) 645-6080 x3011
FL	(904) 488-0300
GA	(404) 656-7802
HI	(808) 586-4235
ID	(208) 334-5898
IL	(217) 785-8604
IN	(317) 232-4417
IA	(913) 551-7058
KS	(913) 296-1608
KY	(502) 564-6716
LA	(504) 765-0272
ME	(207) 287-2651
MD	(410) 361-3345
MA	(617) 292-5574
MI	(517) 373-8410
MN	(612) 297-8512
MO	(314) 751-3176
MS	(601) 961-5052
MT	(406) 444-1430
NE	(402) 471-4217
NV	(800) 882-3233
NH	(603) 271-2942
NJ	(609) 633-1418
NM	(505) 827-4308
NY	(518) 485-8988
NC	(919) 733-2178
ND	(701) 328-5166
OH	(614) 644-2944
OK	(405) 271-5338
OR	(503) 229-5913
PA	(717) 787-6239
RI	(401) 277-2797
SC	(803) 896-4171
SD	(605) 773-3153
TN	(615) 532-0780
TX	(512) 239-6592
UT	(801) 538-6170
VT	(802) 241-3868
VA	(804) 698-4199
WA	(360) 407-6758
WV	(304) 558-5929
WI	(608) 266-2111
WY	(303) 293-1790

RCRA/UST, Superfund, and EPCRA Hotline

This free hotline can provide both teachers and students with information about EPA's programs under RCRA, EPCRA, and Superfund. Hotline staff can answer specific questions about Superfund sites and EPA's cleanup requirements; order documents related to RCRA, UST, EPCRA, and Superfund; and refer callers to appropriate numbers for questions related to other program areas. Call **(800) 424-9346 between 9:00 am and 6:00 pm.**

National Technical Information Service (NTIS)

NTIS provides many of the documents published by EPA for public purchase. To receive a free catalog of available documents, call and request the Compendium of Superfund Program Publications (PR-980). Call **(703) 487-4650** , fax **(703) 321-8547**, or write **National Technical Information Service, Springfield, VA 22161.**

EnviroScape Educational Table Model

This model of different types of geological systems offers children of all ages an interactive educational experience as they learn about water pollution's effects on the environment. Models cost between $199 and $829 and take 4 to 6 weeks for delivery. To receive a brochure or order a model, call EnviroScape at **(703) 519-2180.**

Educational Videos

The Environmental Response Center offers numerous free educational videos that cover a wide variety of topics related to hazardous waste management and the Superfund Program. For more information about the videos or to place an order, call **(800) 999-6990.**

Internet Sites

The Internet is a good source of easy-to-access information concerning the Superfund Program and issues related to hazardous waste sites. The following Internet sites relate to topics discussed in Haz-Ed, and can be accessed using their World Wide Web addresses.

Consumer Recycling Guide

http://www.best.com/~dillon/recycle/

Provides extensive information on recycling-related topics and lists local recycling sites in the United States.

EPA Homepage

http://www.epa.gov

Presents EPA information available through the Internet. Documents available for downloading include press releases, speeches, fact sheets, new regulations, and other materials.

EcoNet's Environmental Education Directory

http://www.igc.apc.org/igc/www.enved.html

Contains links to dozens of environmental education sites, covering a wide variety of topics.

Grand Challenges in Groundwater Remediation

http://www.isc.tamu.edu/PICS/PICS.html

Features dramatic graphic display of groundwater contamination.

Links to State Homepages

http://www.globalcomputing.com/states.html

Contains links to each state homepage which provides access to state government departments or agencies that run environmental programs.

SUPERFUND BROCHURE

This Is Superfund

A Citizen's Guide to EPA's Superfund Program

United States Environmental Protection Agency
Office of Emergency & Remedial Response
Washington, DC 20460

Introduction

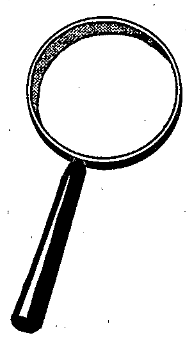
If there is a Superfund site in your neighborhood, you are probably wondering, "What will happen?" and "What can I do?" Hazardous waste sites pose threats to human health and natural resources. The Superfund Program cleans up these sites to protect people and the environment, and to return the land to productive use. This brochure will give you a better understanding of the Superfund process and how you can become involved.

What Is Superfund?

Years ago, people did not understand how certain wastes might affect our health and the environment. Many wastes were dumped on the ground, in rivers, or left out in the open. As a result, thousands of uncontrolled or abandoned hazardous waste sites were created. Some common hazardous waste sites include abandoned warehouses, manufacturing facilities, processing plants and landfills.

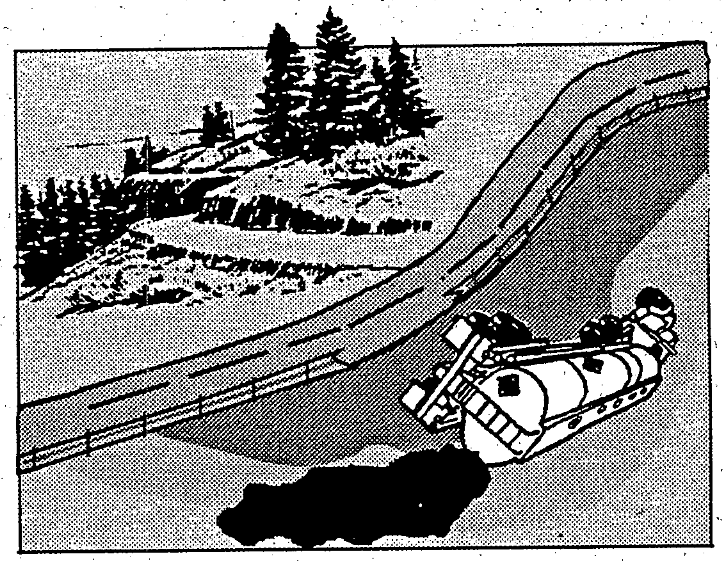
In response to growing concern over the health and environmental risks posed by hazardous waste sites, Congress established the Superfund Program in 1980 to clean up these sites. The Superfund Program is administered by the U.S. Environmental Protection Agency (EPA) in cooperation with individual state and tribal governments. Superfund locates, investigates and cleans up certain hazardous waste sites throughout the United States. The Superfund trust fund was set up to help pay for the cleanup of these sites. The money comes mainly from taxes on the chemical and petroleum industries. The trust fund is used primarily when the companies or people responsible for contamination at Superfund sites cannot be found, or cannot perform or pay for the cleanup work.

How Are Superfund Sites Discovered?



Hazardous waste sites are discovered by local and state government agencies, businesses, the U.S. EPA, the U.S. Coast Guard, and by people like you. You can report emergencies resulting from a release of a hazardous substance to the National Response Center Hotline. To report an emergency, you should call the hotline at **1-800-424-8802**. This hotline is operated 24 hours a day, 7 days a week. You can report potential hazardous waste sites or problems to your state and local authorities. They are listed separately in your phone book.

What Happens When There Is A Chemical Emergency?



A number of the sites reported to the National Response Center are emergencies and require immediate action. Emergency actions are taken to eliminate immediate risks and ensure public safety. Superfund's first priority is to protect the people and the environment near these sites.

EPA's Superfund personnel are on call to respond at a moment's notice to chemical emergencies, accidents, or releases. Typical chemical emergencies may include train derailments, truck accidents, and incidents at chemical plants where there is a chemical release or threat of a release to the environment. EPA may respond or may help state and local authorities deal with these emergencies quickly. The hazardous materials are hauled away from the site for treatment or proper disposal, or they are treated at the site to make them safe. The risk to the community is removed.

In an emergency situation, you and your community will be kept informed of the situation and what steps are being taken to ensure your safety. EPA then evaluates the site and determines whether additional cleanup is necessary.

What Happens To Sites That Are Not Emergencies?

When a potential hazardous waste site is reported, EPA reviews the site to determine what type of action is necessary. EPA look at existing information, inspects the site, and may interview nearby residents to find out the history of the site and its effects on the population and the environment.

Many of the sites that are reviewed do not meet the criteria for Federal Superfund cleanup action. Some sites do not require any action, while others are referred to the states, other programs, other agencies, or individuals for cleanup or other action.

For the sites that do meet the criteria, EPA tests the soil, water, and air to determine what hazardous substances were left at the site and how serious the risks may be to human health and the environment.

Early Actions are taken when EPA determines that a site may become a threat to you or your environment in the near future. For example, there may be a site where leaking drums of hazardous substances could ignite or cause harm to you if touched or inhaled. In this kind of situation, EPA acts to make sure the problem is quickly addressed and the site is safe. Typically, Early Actions are taken to:

- Prevent direct human contact with the contaminants at the site
- Remove hazardous materials from the site
- Prevent contaminants from spreading off the site
- Provide water to residents whose drinking water has been contaminated by the site
- Temporarily or permanently evacuate/relocate nearby residents.

Early Actions may take anywhere from a few days to five years to complete, depending on the type and extent of contamination. During this time, EPA also determines if Long-Term Action will be necessary.

Parties responsible for the contamination at the site may conduct these assessments under close EPA supervision. Their involvement in the study and cleanup process is critical in order to make best use of Superfund resources. EPA uses the information collected to decide what type of action, if any, is required.

At this point, EPA prepares a Community Relations Plan (CRP) to ensure community involvement. This plan is based on discussions with local leaders and private citizens in the community. In addition, EPA sets up a local information file in the community so that people living near the site can get information about the site. The information file or "repository" is usually located at a library or public school and contains the official record of the site, reports, and activities (called the Administrative Record), as well as additional site-related information.

Who Is Involved In Superfund Cleanups?

Superfund cleanups are very complex and require the efforts of many experts in science, engineering, public health, management, law, community involvement, and numerous other fields. The goal of the process is to protect you and the environment you live in from the effects of hazardous substances.

Your involvement is very important. You have the opportunity and the right to be involved in and to comment on the work being done.

Technical Assistance Grant (TAG) Program

EPA values your input and wants to help you understand the technical information relating to the cleanup of Superfund sites in your community so that you can make informed decisions.

Under the Superfund law, EPA can award Technical Assistance Grants (TAGs) of up to $50,000 per site. TAGs allow communities to hire an independent expert to help them interpret technical data, understand site hazards, and become more knowledgeable about the different technologies that are being used to clean up sites.

Your community group may be eligible for a TAG if you are affected by a Superfund site that is on or proposed to be added to the National Priorities List.

More information about TAGs is available from your Regional EPA Community Involvement Coordinator. The telephone number for your coordinator is listed at the end of this brochure.

What Is The National Priorities List?

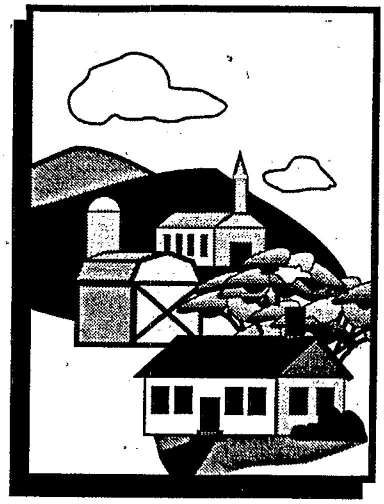
The National Priorities List (NPL) is a published list of hazardous waste sites in the country that are eligible for Federal funding to pay for extensive, long-term cleanup actions under the Superfund program.

How Do The Sites Get On The National Priorities List?

To evaluate the dangers posed by hazardous waste sites, EPA developed a scoring system called the Hazard Ranking System (HRS). EPA uses the information collected during the assessment phase of the process to score sites according to the danger they may pose to public health and the environment. Sites that score high enough on the HRS are eligible for the NPL. Once a site is scored and meets the criteria, EPA proposes that it be put on the NPL. The proposal is published in the Federal Register and the public has an opportunity to comment in writing on whether the site should be included on the NPL. To obtain more information on a proposed site, contact your Community Involvement Coordinator.

The Superfund Process

The Superfund process begins when a site is discovered. After EPA screens and assesses the site, the Regional Decision Team determines if the site requires Early Action, Long-Term Action, or both. Early Actions are taken at sites that may pose immediate threats to people or the environment. Long-Term Actions are taken at sites that require extensive cleanup. EPA encourages community involvement throughout the process.

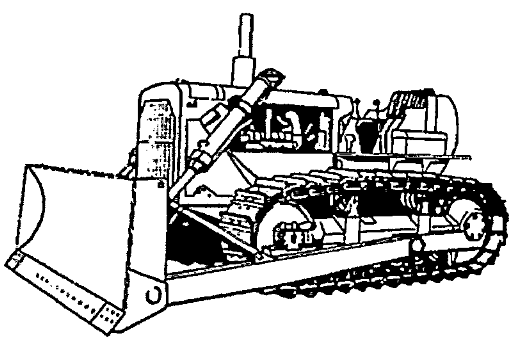


What Happens During A Long-Term Cleanup?

Early Actions can correct many hazardous waste problems and eliminate most threats to human health and the environment. Some sites, however, require Long-Term Action. Long-Term Actions include cleaning up contaminated groundwater and taking measures to protect wetlands, animals, estuaries, and other ecological resources. Long-term cleanups are complex and can take many years to complete. This process is conducted in several phases that lead to the ultimate goal of cleaning up the site and providing a safe environment for the people living near the site. Throughout the process, there is opportunity for community involvement.

First, a detailed study of the site is done to identify the cause and extent of contamination at the site, the possible threats to the environment and the people nearby, and options for cleaning up the site.

EPA uses this information to develop and present a Proposed Plan for Long-Term Cleanup to citizens and to local and state officials for comment. The Proposed Plan describes the various cleanup options under consideration and identifies the option EPA prefers. The community has at least 30 days to comment on the Proposed Plan. EPA invites community members to a public meeting to express their views and discuss the Plan with EPA (and sometimes state) officials.

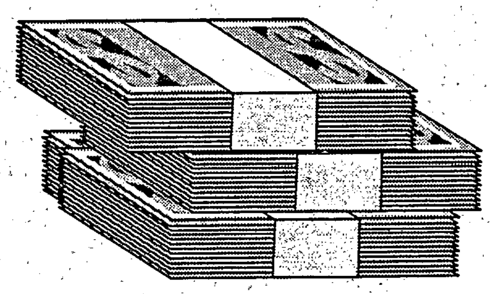


Once the public's concerns are addressed, EPA publishes a Record of Decision, which describes how it plans to clean up the site. A notice is also placed in the local newspaper to inform the community of the cleanup decision.

Next, the cleanup method is designed to address the unique conditions at the site where it will be used. This is called the Remedial Design. The design and actual cleanup is conducted by EPA, the state, or by the parties responsible for the contamination at the site. If EPA does not perform the design, it closely oversees this design phase and the development of the cleanup at the site. When the design is completed, EPA prepares and distributes a fact sheet to the community describing the design and the action that will take place at the site.

EPA can supply the equipment and manpower necessary to clean up a site, but it may take a long time to return a site to the way it was before it was contaminated. Some sites, due to the extent of contamination, will never return to the way they were prior to the pollution; however, EPA will make sure that the site will be safe for the people living around the site now and in the future. EPA regularly monitors every NPL site to make sure it remains safe. If there is any indication that there is a problem, action will be taken to make the site safe again.

Who Pays For Superfund Cleanup?



Superfund cleanup is either paid for by the people and businesses responsible for contamination or by the Superfund trust fund. Under the Superfund law, EPA is able to make those companies and individuals responsible for contamination at a Superfund site perform, and pay for, the cleanup work at the site. EPA negotiates with the responsible parties to get them to pay for the plans and the work that has to be done to clean up the site. If an agreement cannot be reached, EPA issues orders to responsible parties to make them clean up the site under EPA supervision. Superfund ensures that the parties responsible for the pollution pay to fix the problems they created. EPA may also use Superfund trust fund money to pay for cleanup costs, then attempt to get the money back through legal action.

Conclusion

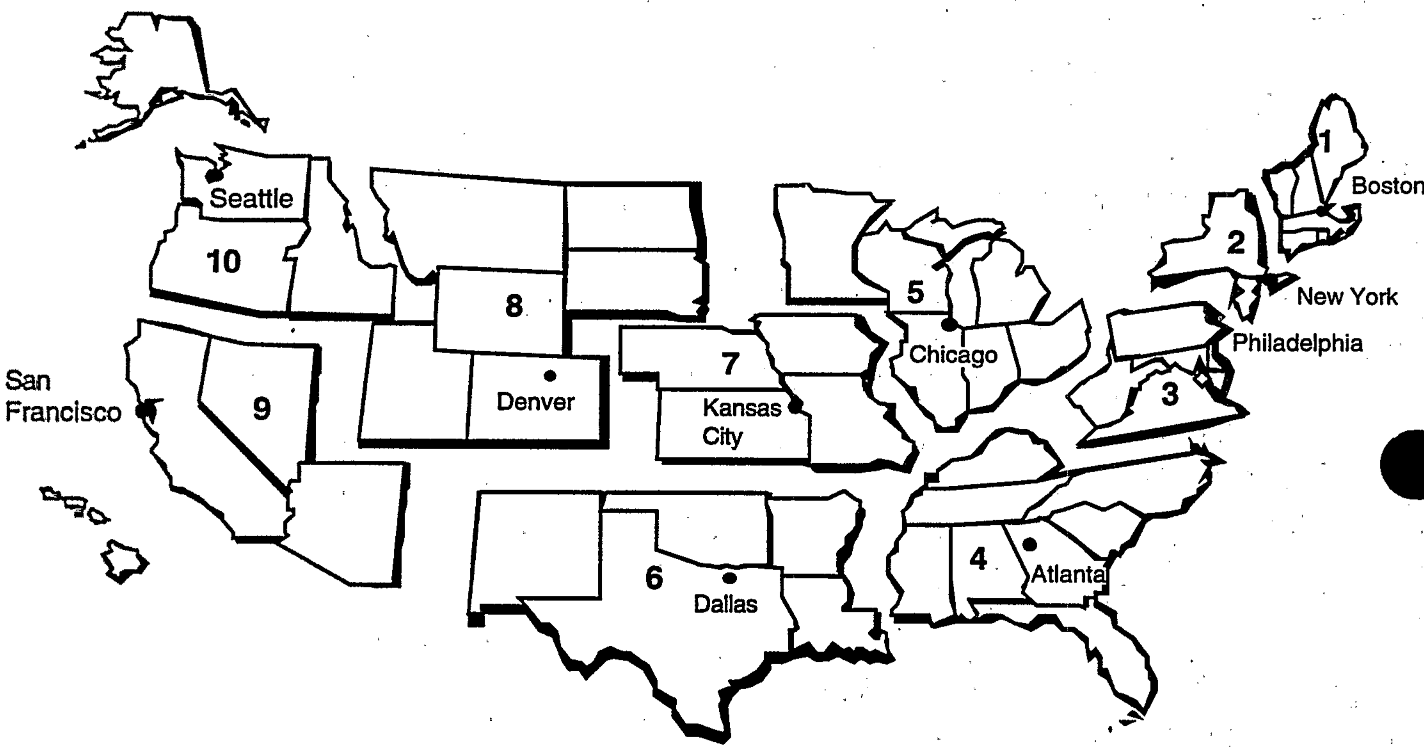
EPA's Superfund Program is the most aggressive hazardous waste cleanup program in the world. Every day Superfund managers are involved in critical decisions that affect public health and the environment. They use the best available science to determine risks at sites. New and innovative technologies are being developed to help find faster and less expensive ways to cleanup sites. Wherever possible, old hazardous waste sites are being restored to productive use. Millions of people have been protected by Superfund's cleanup activities.

The Superfund Program has one ultimate goal: to protect YOUR health and YOUR environment. Protecting communities and the environment is what Superfund is all about.

EPA Superfund Community Involvement Offices

EPA wants to remain accessible and responsive to your concerns. Our community involvement staff is available to answer any questions you may have regarding a Superfund site or an area you think may be a site. Here is a list of the Community Involvement Offices at EPA's Regional Offices.

EPA Regional Offices



Region 1	**(617) 565-3425**	**Region 6**	**(214) 665-6617**
Region 2	**(212) 637-3675**	**Region 7**	**(913) 551-7003**
Region 3	**(215) 597-9905**	**Region 8**	**(303) 312-6600**
Region 4	**(404) 347-3555 x6264**	**Region 9**	**(415) 744-2175**
Region 5	**(312) 886-6685**	**Region 10**	**(206) 553-1272**

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NOTE: For copies of EPA documents, contact the National Technical Information Service (NTIS) at 1-800-553-6847. Give them the title and publication number of the documents you wish to order. There may be a charge for some documents.

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